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Mobile Radio Technology™

The journal of mobile communications technology

Tower monitoring, p. 10

Lightning protection
Servicing pagers
Two-way simulcasting
Fiber-optics

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Contents

Mobile Radio Technology

Volume 12, Issue 4

The journal of mobile communications technology

features

On the cover: Remote monitoring helps to manage electronic equipment and security at radio communications facilities. *Photo courtesy of Remote Monitoring of America, San Antonio, TX.*

departments

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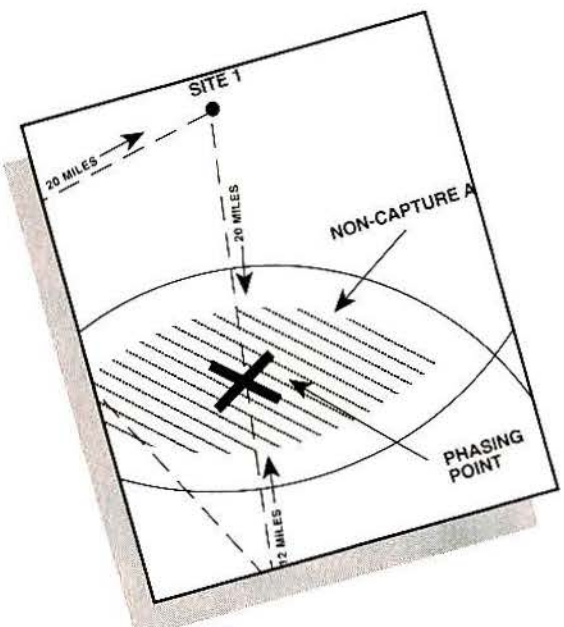
page 32



page 58

Editorial

The new kids on the block and the old hands

Public communications networks, such as specialized mobile radio (SMR), cellular mobile telephone and radiopaging, are receiving higher levels of consumer media attention. The biggest story as this is being written is MCI's investment of $1.3 billion in Nextel Communications for a 20% stake in that company. At the Wireless '94 conference sponsored by the Cellular Telecommunications Industry Association in March, Nextel Chairman Morgan O'Brien said MCI fills out a complement of strategic allies that was missing a partner with national marketing clout. Nextel's enhanced specialized mobile radio (ESMR) products, made by another of the company's equity partners, Motorola, will be marketed as MCI wireless communications products.

Nextel, with control of 10,000 SMR channels, expects to complete the construction of its digital public communications network in 1996. With the cooperation of other ESMR operators, the network will offer nationwide, seamless mobile and portable telephone service. O'Brien said developments in Canada and Mexico are expected to add those countries to the network for full North American coverage.

What fails to attract consumer news media attention is the ongoing construction and operation of private communications networks that support commercial and public safety activities. These systems are well-known to *MRT* readers as VHF, UHF, 220MHz and 800/900MHz conventional and trunked radio systems and customer-owned radiopaging systems.

These networks range from the "base-and-three" configurations of two-way radio dispatch systems that so many people say belong to the dinosaur age (despite their proven value to owners), to complex, multisite, wide-area mobile data communications networks used by national and regional delivery services and public safety agencies. Participants in the private network part of the wireless communications industry say sales are very healthy... or nonexistent... or somewhere in between. The difference probably has to do with the kind of system being sold. One company that offers improvements to private communications networks for land transportation companies reports having sold so many systems in large cities that it now concentrates on secondary markets.

We've mentioned that some two-way radio dealers are changing their approach, calling themselves "wireless system integrators," to reflect their ability to draw various technologies into a private network to serve particular customer needs. If these private networks can provide customer features, operational control, lower cost or a combination to their owners that compares favorably with public networks, private network equipment sales should remain healthy.

At the American Mobile Telecommunications Association (AMTA) conference in February, Dale Hatfield, communications business consultant, predicted that private communications networks will continue to show strength, especially those that serve utilities and public service agencies. As the wireless communications market grows, Hatfield foresees the private network segment reflecting a smaller share because of its slower growth compared to the other segments, but no shrinkage in its underlying value.

One obstacle to continuing private network VHF and UHF equipment sales, the uncertainty about technical requirements that may change as spectrum refarming is implemented, seems to have melted away. Some manufacturers representatives report the return of good sales figures for base stations and for mobile and portable units that use the lower frequency bands.

One manufacturer suggests that VHF and UHF private network equipment will benefit next from features flowing from cellular product development. Just as SMR product has benefited from circuitry developed for cellular phones, so VHF and UHF products may benefit from circuitry developed for 800MHz trunked radio.

Marketing programs for services may improve, too. Many SMR operators who sold their licenses to consolidators, such as Nextel, Dial Page and CenCall, retained their VHF and UHF business interests. What they learned from operating SMR systems can be turned to improving their lower frequency band systems. Others think uncertainty about spectrum refarming will discourage new product development for VHF and UHF. We're coming full circle here because the dip in sales following the spectrum refarming proposal may have been temporary.

Congress handed the FCC so much work with its Communications Act revision that a spectrum refarming decision continues to be delayed. At the AMTA conference, FCC Private Radio Bureau Chief Ralph A. Haller said the work on the docket might be completed this summer.

At Wireless '94, Dennis Patrick, the president of Time Warner's telecommunications division, spoke of a future commoditization of wireless communications network services, meaning that the communications path offered by cellular, digital SMR and personal networks eventually may differ little in cost and capability. Content of the communications will make the difference, and service providers that cater to the content desired by customers will succeed. Patrick foresees a low-cost, high-volume voice communications capability with a wireless component as part of Time Warner's future telecommunications offering.

Another factor changing the complexion of private communications networks and how traditional equipment dealers participate is the 220MHz system license lottery. Radio equipment dealers used to have the upper hand in obtaining frequencies and licenses for their customers and for themselves (to offer community repeater service). Now, new licensees, largely without experience in wireless communications, are building systems because they won licenses in the lottery. Many of them call upon the engineering and technical services of the "wireless systems integrators" to help them build and operate their new 220MHz systems. Some dealers may contract to sell equipment and airtime on the new systems; they do not control their destiny as when they hold licenses themselves.

This is an exciting time for wireless communications developments, with projections of enormous market penetrations for consumer equipment on public networks that will earn recurring airtime revenue for system operators. At the same time, private communications network equipment sales can be expected to remain healthy, although without the excitement of consumer news media attention.

—Don Bishop

Calendar

April

13-15—International Wireless Communications Expo/Spring, Las Vegas Convention Center, Las Vegas. Contact: 1-800-828-0420.

May

2-5—Supercomm, sponsored by USTA and TIA, and **International Conference on Communications,** sponsored by IEEE, New Orleans. Contact: USTA, 202-835-3100.

12-14—Mobile Communications Conference, sponsored by the National Association of Business and Educational Radio (NABER), Peabody Hotel, Orlando, FL. Contact: Nancy Palleschi, 800-759-0300.

25-27—RadioComm, Vancouver Convention Center, Vancouver, British Columbia. Contact: Bill Eggertson, 613-233-4888.

June

7-11—Vehicular Technology Conference, sponsored by IEEE Vehicular Technology Society, Stockholm, Sweden. Contact: Professor Sven-Olof Ohrvik, technical chairman, 46 8 757 0483; Fax 46 8 34 8441.

18-20—International Public Safety Exposition and Conference, sponsored by the International Association for Public Safety, Dallas Convention Center, Dallas. Contact: 203-847-9679.

19-23—Utilities Telecommunications Council, Washington Sheraton, Washington, DC. Contact: Christine Benz, 202-872-0030.

28-30—Wireless Datacomm Spring, San Jose Convention Center, San Jose, CA. Contact: 800-322-9332.

July

17-20—Forestry-Conservation Communications Association, Hershey, PA. Contact: Don Pfohl, 602-644-3166.

August

6-11—International Municipal Signal Association, Cavenaugh's Inn, Spokane, WA. Contact: Harold Glerum, 800-723-4672.

7-12—Association of Public-Safety Communications Officials—International National Conference, Lawrence Convention Center, Pittsburgh. Contact: 800-824-1850.

September

22-24—Mobile Communications Marketplace, Washington State Convention Center, Seattle. Contact: 800-326-8638.

October

3-5—WirelessWorld Conference & Exhibition, sponsored by *Cellular Business* magazine, The Stouffer Orlando Resort, Orlando, FL. Contact: Stephanie Hanaway, 913-967-1856.

15-20—International Association of Chiefs of Police, Albuquerque Convention Center, Albuquerque, NM. Contact: 703-243-6500.

19-21—International Wireless Communications Expo/Fall, Tampa Convention Center, Tampa, FL. Contact: 303-220-0600.

November

18—Radio Club of America, Communications Symposium, Annual Dinner and Awards Presentation, New York Athletic Club, New York: Contact: Ron Formella, 201-652-6811.

December

6-8—Wireless Datacomm Fall, Washington Convention Center, Washington, DC. Contact: 800-322-9332.

1995

February

1-3—Cellular Telecommunications Industry Association Winter Meeting and Exposition, New Orleans. Contact: 202-785-0081.

April

3-5—Energy Telecommunications and Electrical Association, George R. Brown Convention Center, Houston. Contact: 214-235-0655.

Mobile Radio Technology

The journal of mobile communications technology

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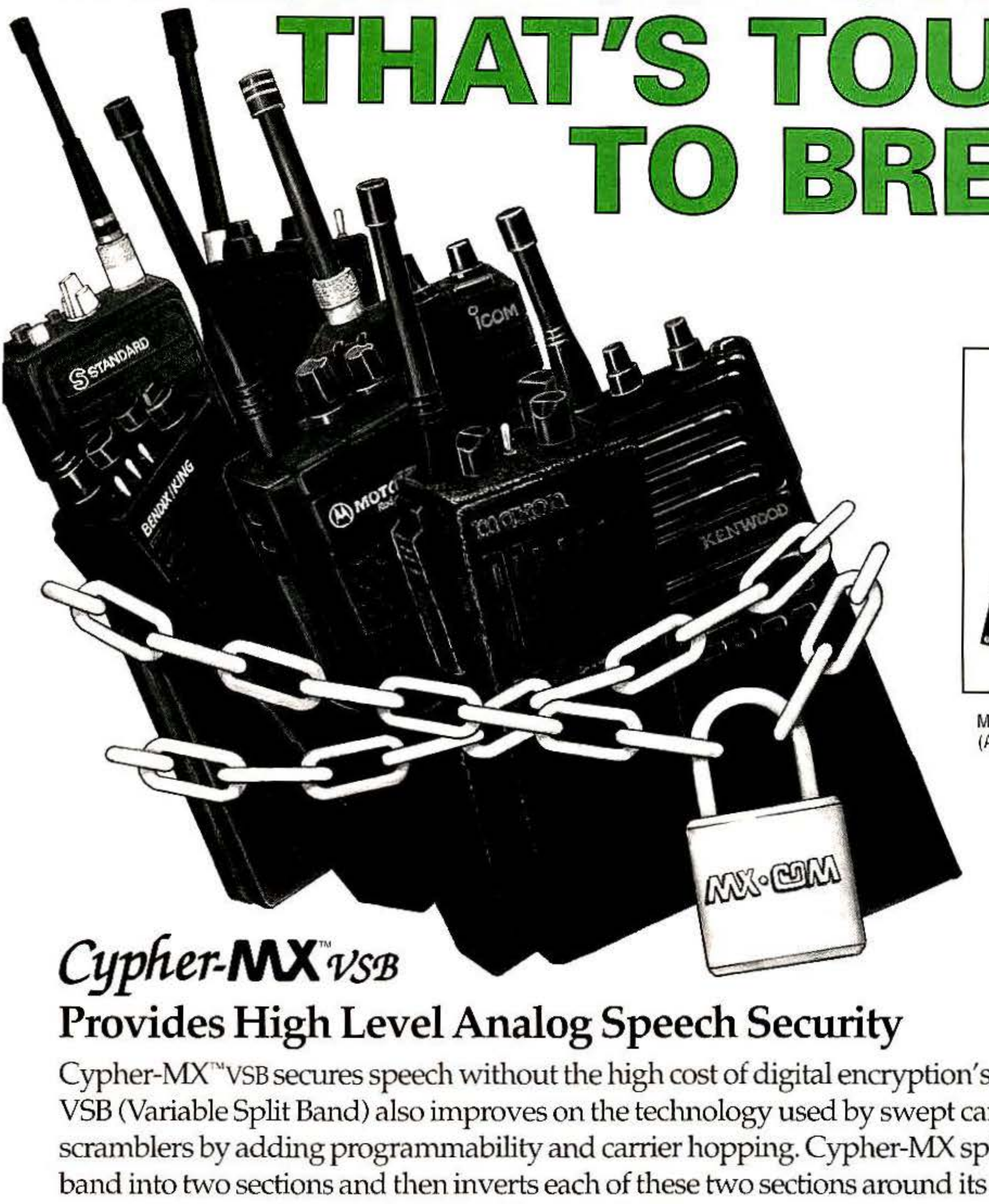

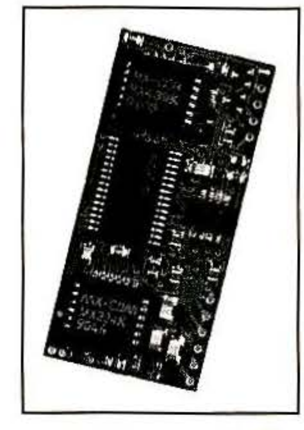

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Field intensity formulas and their use

By Harold Kinley, C.E.T.

Last month's column provided graphs to convert between *field intensity* expressed in microvolts per meter ($\mu V/m$), or expressed in decibels referenced to $1\mu V/m$ (dBu), and *signal level* expressed in dBm or microvolts. This month the conversion formulas are provided with typical examples.

These formulas are based on a system impedance of 50Ω. These formulas are listed below. All you need to use them is a scientific calculator.

To use a 50Ω-input spectrum analyzer for field intensity measurements, a *calibrated* antenna is necessary. A calibrated antenna has a known antenna correction factor (K) in decibels per meter (dB/m). The antenna correction factor (K) can be calculated from either Formula 11 or Formula 12, as shown in the listed equations. Only two formulas, 9 and 10, require the antenna correction factor (K). The other formulas automatically include the antenna correction factor without specifically calling for it.

With a 75Ω antenna system, use Formula 12 to calculate the antenna correction factor, and use an impedance-matching transformer or minimum-loss resistive matching pad to match the 75Ω antenna to the 50Ω spectrum analyzer input. The insertion loss of the transformer or resistive matching pad must be taken into account as part of L in Formulas 1, 2, 9 and 10.

If you are using a factory-made antenna for field intensity measurements, look for the antenna correction factor on a graph or chart that should be included with the antenna. (K varies with frequency.) When using a factory-made antenna with a known K-factor, Formulas 9 and 10 are appropriate.

Figures 1A and 1B on page 84 show how to build simple antennas for making field intensity measurements with the spectrum analyzer. These are 75Ω antennas; thus, they require an impedance-matching transformer or pad between the antenna and the spectrum analyzer.

For example, if you build the antenna in Figure 1B for use at 460MHz, first find the antenna correction factor (K) by using Formula 12. Because this *is* a halfwave dipole, the gain is 0dBd; thus:

$$
\begin{aligned}
K &= 20\log F - 33.7\\
&= 53.3 - 33.7\\
&= 19.6\text{dB/m}
\end{aligned}
$$

Refer to Figure 2 on page 86. Suppose the impedance-matching transformer has an insertion loss of 1dB and the line loss is 1dB. This brings the total loss (L) between the antenna and spectrum analyzer input to 2dB. If the spectrum analyzer indicates a signal level of −75dBm, the field intensity in $\mu V/m$ can be found by substituting the values for dBm, K and L into Formula 9. Be sure to observe the value signs. (The values for dBm and K can be negative or positive; L is always positive.)

When substituting these values into Formula 9, keystrokes on a typical scientific calculator would follow this sequence:

75 +/- + 107 + 19.6 + 2 = ÷ 20 = INV LOG, which displays 478.6300923. Thus, the field intensity is $478.6\mu V/m$.

To convert to dBu, use Formula 7. Calculator keystrokes are as follows:

478.6 LOG × 20 = 53.59945388, or 53.6dBu.

Example for Formula 1: A 50Ω antenna system with a gain of 6dB (properly oriented) is placed in a field with an intensity of $100\mu V/m$ at a frequency of 475MHz. The loss in the line between the antenna and receiver input is 1.5dB. What is the signal level in microvolts (μV) at the receiver input? Substituting these figures into Formula 1, the calculator keystrokes are as follows:

100 LOG × 20 = + 6 − (475 LOG × 20) + 32 − 1.5 = ÷ 20 = INV LOG, which displays 14.07039827, or $14.1\mu V$.

Example for Formula 2: A signal level of at least $2\mu V$ is required at the input of a receiver. The frequency is 155MHz. The antenna gain is 6dB, and the line loss is 2dB. What is the required minimum field intensity ($\mu V/m$) at the antenna? Substituting these figures into Formula 2, the keystrokes would be:

2 LOG × 20 = − 6 + (155 LOG × 20) − 32 + 2 = ÷ 20 = INV LOG, which displays 4.913168896, or $4.9\mu V/m$.

(continued on page 84)

Formula 1

$$\mu V = \text{antilog}\left[\frac{20\log(\mu V/m)+G_R-20\log F+32-L}{20}\right]$$

Formula 2

$$\mu V/m = \text{antilog}\left[\frac{20\log(\mu V)-G_R+20\log F-32+L}{20}\right]$$

Formula 3

$$\mu V \cong \left[\frac{40(\mu V/m)}{F}\right]$$

Formula 4

$$\mu V/m \cong \left[\frac{F(\mu V)}{40}\right]$$

Formula 5

$$\text{dBm} = 20\log(\mu V) - 107$$

Formula 6

$$\mu V = \text{antilog}\left[\frac{\text{dBm}+107}{20}\right]$$

Formula 7

$$\text{dBu} = 20\log(\mu V\ m)$$

Formula 8

$$\mu V/m = \text{antilog}\left[\frac{\text{dBu}}{20}\right]$$

Formula 9

$$\mu V/m = \text{antilog}\left[\frac{\text{dBm}+107+K+L}{20}\right]$$

Formula 10

$$\text{dBm} = 20\log(\mu V/m) - 107 - K - L$$

Formula 11

$$K = 20\log F - G_R - 32$$ (50Ω antenna system)

Formula 12

$$K = 20\log F - G_R - 33.7$$ (75Ω antenna system)

where:

- μV = microvolts
- $\mu V/m$ = field intensity in microvolts per meter
- dBu = field intensity in decibels referenced to $1\mu V/m$
- dBm = decibels referenced to 1mW in 50Ω
- F = frequency in MHz
- G_R = gain of receiving antenna referenced to a half-wave dipole (dBd)
- K = antenna corrrection factor
- L = loss (dB) between the antenna and receiver input

Kinley is a certified electronics technician with the South Carolina Forestry Commission, Spartanburg, SC. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, Prentice-Hall, 1985.

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How to use monitoring to manage remote towers

Companies that use new ways to operate radio communications towers can offer better customer support and service, introduce new services and products faster, and keep maintenance and operations organizations lean.

By John T. Saunders Jr.

Managing operations at remote towers has never been easy. Government regulations, complex equipment, customer expectations for flawless service, diverse and widely separated system assets, and inadequate resources for system maintenance combine to make operating remote towers and radio systems a technical and logistic nightmare.

Problems that can occur with remote sites are many and, unfortunately, all too familiar to most system operators: fines for tower lights that have burned out, beacons that flash too fast or too slow, fines and huge cleanup costs for fuel storage tanks that have leaked, degradation or failures in equipment that are discovered only after customers have complained about low-quality service, unauthorized individuals climbing towers or "adjusting" equipment, and on and on. Domestic and international competition further aggravates operational problems as many companies lay off employees and re-engineer and upgrade their products to compete.

New approaches

Many companies are being forced to seek new and innovative ways to manage diverse, remote operations and overcome their problems. They have found that the costs of maintaining and managing systems can be better controlled with a coordinated use of resources and with applications of new technologies. Continuous, electronic monitoring has, in many cases, replaced the common practice of "spot-checking" unattended equipment to ensure proper operation. Monitoring capabilities are built into much of the new radio equipment now available, and many of the more-sophisticated systems have large, comprehensive monitoring centers in place to manage large radio networks.

Saunders is president of Remote Monitoring of America, San Antonio, TX.

The benefits for companies that adopt new solutions to manage their remote operations are many and diverse, including:

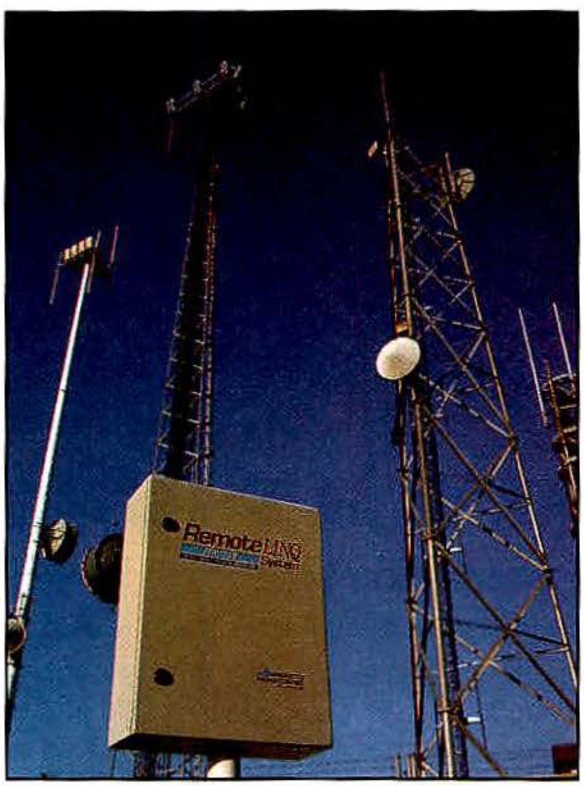
□ greatly reduced risk of fines and levies from improper operations.

□ better, faster and cheaper operations data.

□ fast response to problems and needs.

□ better records, alarms and reports.

□ more reliable process and pollution control.



Remote monitoring helps to manage electronic equipment and security at radio communications facilities.

Modern monitors

Key elements in today's intelligent but economical monitoring systems involve myriad technologies, such as microcontrollers, real-time operating software and new monitoring algorithms. Integrating these technologies creates products with more features and capabilities at a lower price than previously has been available. Features typically available on these new monitors include:

□ continuous, 24-hour monitoring of all operations.

□ easy configuring to individual sites and conditions.

□ easy access from common communications networks.

□ flexible alarm status and data reporting.

□ friendly user interfaces for all users.

Modern monitoring systems now provide an "electronic" window that operators can "open" at any time into the site activities. Within seconds, the operator can determine how much current the tower lights are consuming, how fast the tower beacon is flashing and what the trends in the radio transmitter forward and reflected RF power have been over the past week.

The latest monitoring systems watch these and other tower functions continuously, notifying operators as soon as an abnormal condition or a malfunction occurs.

Table 1 — Tower and radio functions to monitor.

TOWER	RADIO
Humidity in radio shelter	Radio alarms and other radio functions
Fire, heat, smoke in radio shelter	Forward and reflected power of radio systems
Water leaks into radio shelter	Key intervals on radio transmitter
Intrusion into radio shelter and racks	Currents in tower light circuits
Status of site power	Flash rate of tower beacons
Status of backup generator	Ambient light with photocells
Level of backup generator fuel tanks	Temperature in radio racks
Voltage of backup batteries	Temperature in radio shelter

The most sophisticated monitoring systems even employ predictive maintenance methods and techniques, detecting changes in tower operations before they become emergencies. Table 1 above shows an abridged list of the many operations tower monitors now "watch" for operators.

The right monitoring system

A remote monitoring system must integrate the best available sensor, data collection, data processing and wireless communications technology into a turn-key system. The system must provide continuous, autonomous operations with sophisticated data processing, self-diagnostics and intelligent automated reporting. The system has to run reliably in harsh conditions with intermittent power and save data for long periods even without power. In addition, the system designer must really understand what is being monitored to compose useful and intelligent information and alarms. Table 2 on page 14 suggests the minimum features required of any new monitoring system.

Price

Note that price is often not a large factor anymore because system prices have decreased and functionality and sophistication have increased.

Finding a company committed to supporting its products, enhancing product functionality and improving user features for data presentation, reports and communications is at least as important as finding a low-cost unit. The cost and time involved in installing a monitoring system make developing a long-term relationship with the monitoring system manufacturer

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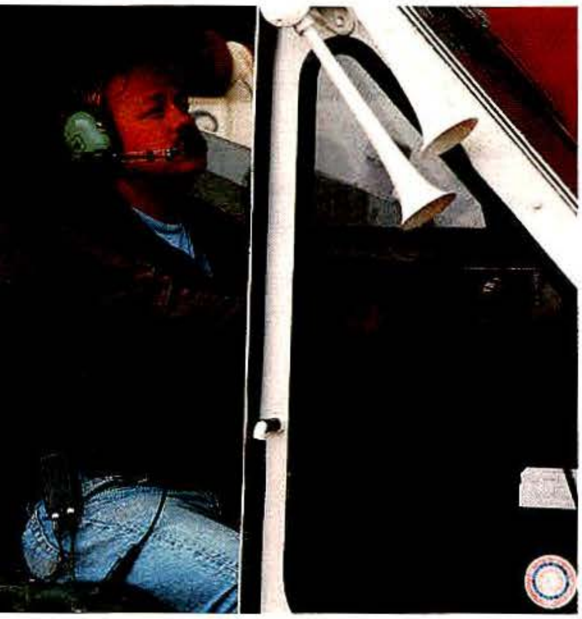

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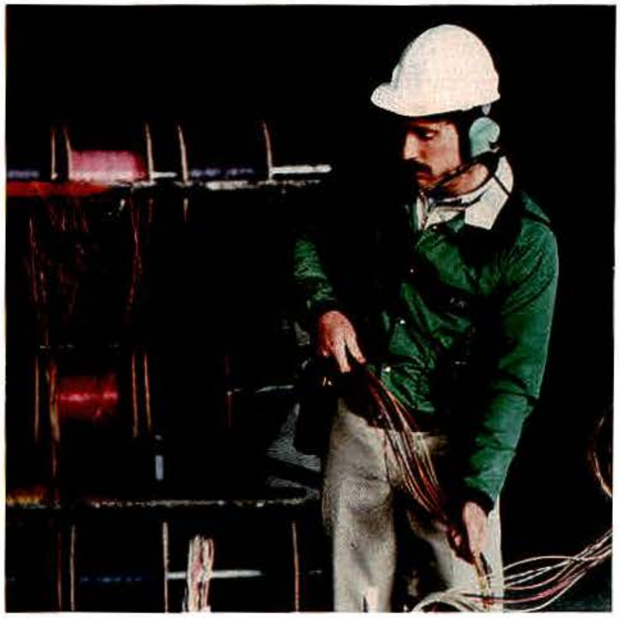

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Table 2 — Minimum requirements for a modern tower monitoring system.

REQUIREMENTS	PURPOSES
Analog inputs	Measure analog processes such as equipment temperatures, battery voltages, levels in fuel tanks and currents in power circuits.
Digital inputs	Monitor radio, burglar and other alarms.
Digital outputs (Control)	Control critical tower operations as required.
Custom alarm programs	Tailor the monitoring system to each individual site, including interdependent alarms and any number of alarms for a specific sensor.
Archived sensor data	Build a history of site operations and provide documentation for reports or investigations.
Approved measurement routines of regulated operations	Guarantee constant compliance with government regulations.
Reliable communications	Access to one or more communications networks for fast reporting of problems and direct operator access to site status from anywhere, anytime.
Expandability	Ability to expand and otherwise support product.

desirable. In fact, many manufacturers are willing to develop product enhancements based on user specifications, leading to monitoring systems that truly meet the needs of the tower operator.

Applying knowledge

A future goal is to apply the knowledge of technicians and engineers to remote monitoring technology to take raw data and turn it into useful business information. Such integration uses a wide range of engineering and operations expertise and requires cooperation among individuals and entire organizations.

Advantages for companies that collaborate to develop new ways to operate remote assets include better customer support and service, fast introduction of new services and products, and lean, effective maintenance and operations organizations. These advantages will help these companies to achieve success.

Protection system disconnects equipment as lightning nears

For some equipment, disconnecting and grounding the inputs may offer a simple, inexpensive method of protection from lightning-induced electrical surge currents. A new protection system works automatically.

By Dan Young

Damage to electrical and electronic equipment from lightning and other atmospheric charges and discharges continues to be a problem despite numerous available countermeasures. Grounding devices, surge suppressors, lightning arrestors, standby power sources and line conditioners all have been tried, and, when installed properly, each protects equipment with some effectiveness. *Grounding* has the greatest effect upon the success of most conventional protection equipment and devices.

Problems persist because so many variables affect grounding: soil composition, buildings with poor grounds (or no ground at all) and areas that seem unusually attractive to lightning.

When equipment must remain operational or connected to power lines, coaxial cables or telephone lines during a storm, all one can do is to install the best protectors and *hope*.

For equipment that can be taken off-line automatically during a storm, an incipient lightning detection/protection system can help. Typically, it detects lightning 2 miles to 5 miles away, automatically disconnects ac power lines, coaxial cables and telephone lines from the source, and grounds those inputs to the equipment. After the storm passes a safe distance, the system automatically restores all connections.

If equipment cannot be taken off-line for any reason, the system still indicates when a storm is coming so that data can be backed-up or other appropriate actions can be taken. For example, a standby generator can be brought on-line when a storm is coming.

In systems powered by batteries connected to a float charging system, the charger can be protected by disconnecting its ac power input during a storm. Cycling is good for batteries, and the equipment powered by the batteries will not be affected if the charger is disconnected for a short period.

Alternatively, the protection system can automatically disconnect equipment during a storm, but allow an operator to override the disconnection either on-site or by remote control. Remote control can be operated by RF signaling or by a dedicated telephone line.

Proper grounding and lightning arrestors are certainly necessary to protect the antenna, tower and feedlines, but there is a certain peace of mind that comes with knowing the equipment is "unplugged" when the site is unattended and a storm is approaching.

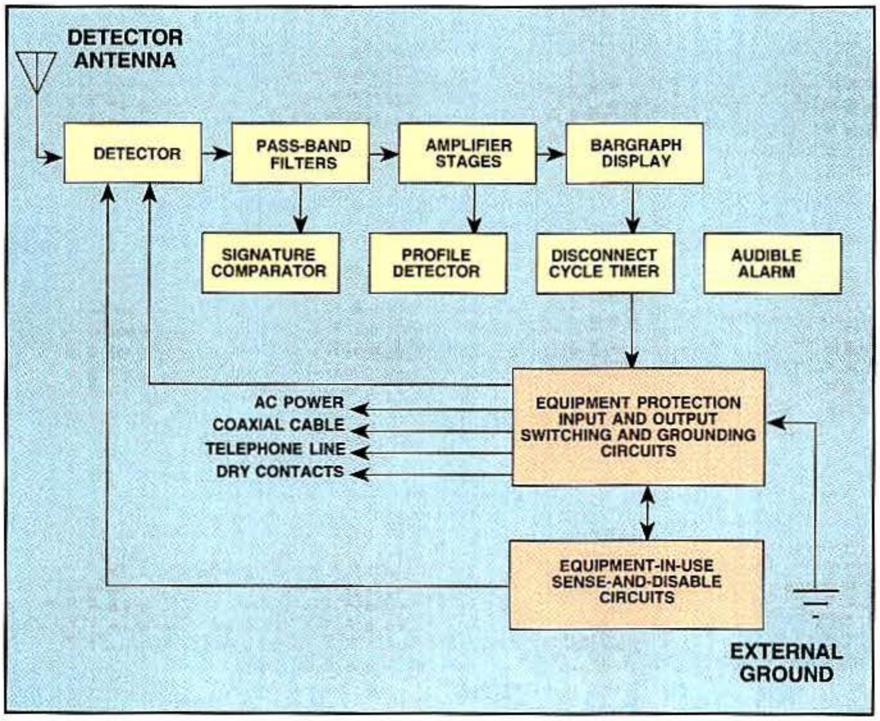

Figure 1. The detector antenna picks up radio energy from lighting, which is filtered and analyzed. A bargraph and alarm indicate when lightning is near. Switching and grounding circuits disconnect and protect equipment.

How it works

Lightning releases a tremendous amount of radio energy from the lowest frequencies up to 1MHz.

Many man-made devices, intentionally or not, emit radio energy in the same range. The detection system is designed to detect radio energy from lightning and to filter out frequencies known to be occupied by man-made radio energy. (See Figure 1 to the left.) The system identifies specific sig-

Young is president of Rabun Labs, Orlando, FL, which makes the lightning detection and protection system described in this article.

nal profiles and lightning signatures. A bargraph displays atmospheric disturbances as they are detected.

Once the electronic evaluation confirms that the received radio energy is from nearby lightning, the disconnect cycle timer activates. All the equipment-protection switching circuits then perform the actual disconnecting, shunting and grounding functions for the power line, coaxial cable and telephone line inputs. An audible internal alarm sounds each time lightning is detected.

Furthermore, the system protects its own detector from damaging high-level atmospheric discharges while operating in the *protection/disconnect* mode.

Relay protection

Surge currents are prevented from jumping across the disconnect relay contacts because the connections to protected equipment are disconnected, shunted and grounded.

Shunting can be explained as follows: If you were to pull a plug out of a wall outlet, all three prongs (ground, neutral and hot) would be disconnected from power. If you were to connect all three prongs together (shunt them), and then connect them to ground, you would accomplish something similar to what the system does in *protect mode* to the ac power input of the protected equipment.

If a surge current *were* to jump the relay contacts, with all three legs of the power input at the same ground potential, the current would take the path of least resistance and go to ground—not into the equipment. The same shunting methodology is used on coaxial cables and telephone lines. For the best protection, the system uses an external ground connection.

Sense and disable

An "equipment-in-use sense-and-disable circuit" prevents premature or inadvertent disconnection of equipment that could be damaged by a loss of power, such as computers. The circuit requires connected equipment to draw at least 75W from the 120Vac line before it will activate.

Below the 75W threshold, equipment is disconnected automatically, which is an advantage for communications equipment. Solid-state transceivers in receive mode draw less than 75W, so when lightning is detected, the equipment is disconnected and protected automatically to save the sensitive receiver front-end from damage.

Another version of the system is designed for other on-line equipment such as repeaters, microwave links and satellite links. In that version, the sense-and-disable function is bypassed, and the equipment is disconnected and protected as soon as lightning is detected.

Antenna

The detector antenna is important because if the system cannot detect lightning properly, it cannot protect equipment connected to it.

The detector antenna is a 20-inch to 36-inch vertical whip that works with 50Ω or 75Ω coax. As with most receiving antennas, the higher the antenna is elevated the better. Placing it as far as possible from noise generators such as fluorescent lights, lamp dimmers and motor speed controls helps. Typically, the antenna is mounted on an eave of a building no farther than 75 feet from the detection unit.

For a do-it-yourself antenna, measure the length of coax required to reach from the detection unit to the antenna location. Install a male BNC connector at the

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detector end of the coax. On the other end, strip 36 inches of outer insulation and shield, leaving the insulated inner conductor exposed.

The 36 inches of exposed inner conductor serves as the antenna. Mount it vertically, and use standoff insulators if necessary to keep it away from metal surfaces.

Where coaxial cable installation is difficult, not advisable or not allowed, another alternative can be used.

Select a telephone instrument near the detection unit. Closely wrap about 12 turns of No. 20 insulated solid copper hookup wire around the phone cord where it comes out of the wall. Strip about $^1/_2$-inch of insulation from the other end of the hookup wire. Plug the wire securely into the center terminal of the detector unit's BNC antenna connector.

This method uses the telephone wiring as an inductively coupled antenna. It has performed satisfactorily in many installations, and it is remarkably immune to outside noise.

Detector as 'troubleshooter'

The bargraph display and the rest of the system have some additional uses.

Because several models respond to power line anomalies and atmospheric disturbance, the system can be used as a low-cost troubleshooting tool to identify and isolate the source of power disturbances or interruptions that cause unexplained equipment behavior or malfunctions.

Equipment that may be affected includes computers, microprocessor-based control systems, satellite links, telephone equipment, cellular software-controlled switching equipment for power and cellular systems, petroleum industry data transmission equipment and communications repeater switching and control equipment. The bargraph and audible alarm provide real-time notification, and the system can be connected to chart recorders or data loggers to pinpoint the dates and times when anomalies occur at unattended locations.

The system also can detect power line disturbances. When the detector antenna is disconnected, the system responds only to ac power line anomalies. Reconnect the antenna to monitor atmospheric-induced anomalies.

The system can be configured to protect communications equipment, computers and data processing equipment, stand-by generators, monitors, alarms, battery chargers, motors and loads.

It is ironic that the equipment protection technique that many have always trusted is the most simple: Disconnect or unplug the equipment. For some, it is the only solution that makes sense.

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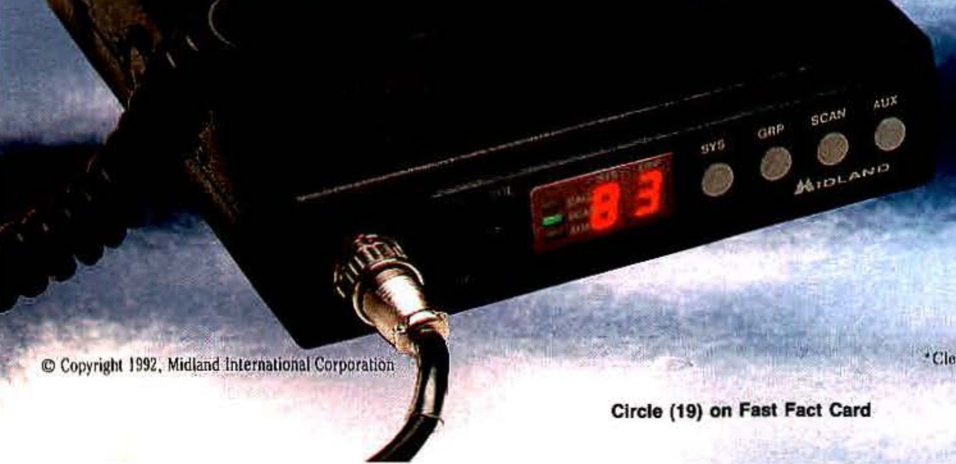

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Servicing pagers: From bench to programmer

Part 4—Follow these steps to choose an appropriate pager frequency, install the right crystal, verify proper receiver and decoder operation, and program the pager to work with a customer's pager telephone number.

By David Ludvigson

With a customer's Bravo pager in hand, turn the slide switch all the way up to the *beep mode*.

A rapid series of continuous beeps indicates a weak battery; replace it if necessary.

With a good battery, the pager should emit four sets of "beep-beep" noises, and the display lamps should flash before the pager settles down to "lights out" and a broken horizontal bar across the display.

Up to this point, the microprocessor has gone through its "wake-up" sequence. Failure at any point of this wake-up sequence usually indicates a failure of the decoder board.

Turn the pager off, and then turn the pager's slide switch all the way up (to beep mode) while depressing both the gray and black push-buttons beneath the liquid crystal display (LCD). Quickly release both push-buttons and rapidly depress the gray button. Upon release, the word *paging* (with an optional suffix) will appear in the LCD.

Another depression of the gray button will reveal a set of 1s and 0s. These are the options (in binary format) that have been programmed into the unit. Another depression will reveal the capcode (in decimal format). This condition, in which all the internal data may be read, is called the *service mode*.

While the Bravo is in service mode and *paging* is displayed on the LCD, use a jeweler's hexdriver to remove the two screws holding the case together. Remove the back cover.

At this point, insert the pager into the radiation test fixture with the IFFER attached to test point M1. Using the presets of the Ramsey Com 3 service monitor, generate an RF signal modulated with a 1kHz tone at 4.5kHz deviation and scan through the available frequencies to locate the pager's operating frequency.

The IFFER will show (on an external oscilloscope) how well the first local oscillator has been adjusted. Failure to locate the signal will require disassembly of the pager.

Turn the pager off. Remove the battery clip at the bottom of the case, and remove the battery. Remove the diffuser lens behind the LCD.

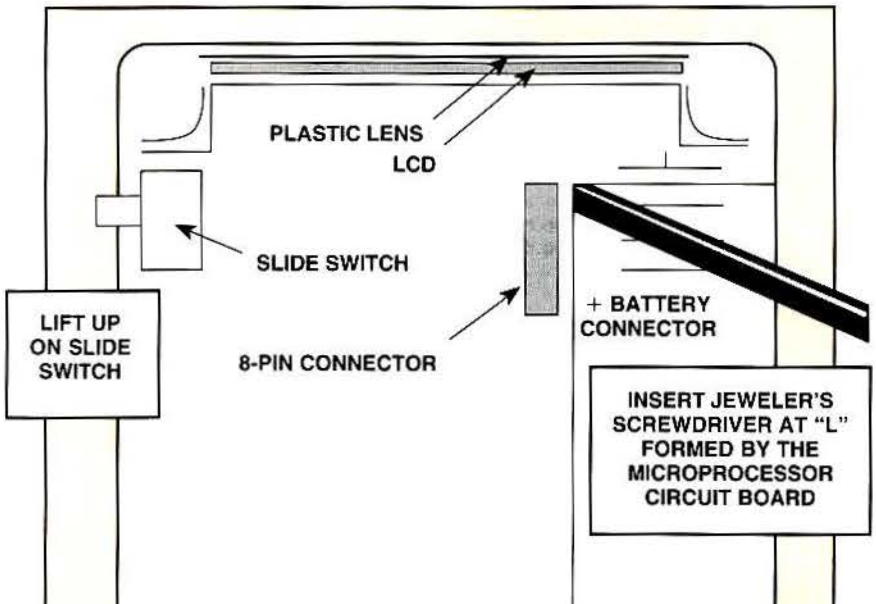

Figure 1. Use a jeweler's screwdriver to remove the decoder and receiver circuit boards from the Bravo pager housing.

Ludvigson is a technician in Houston.

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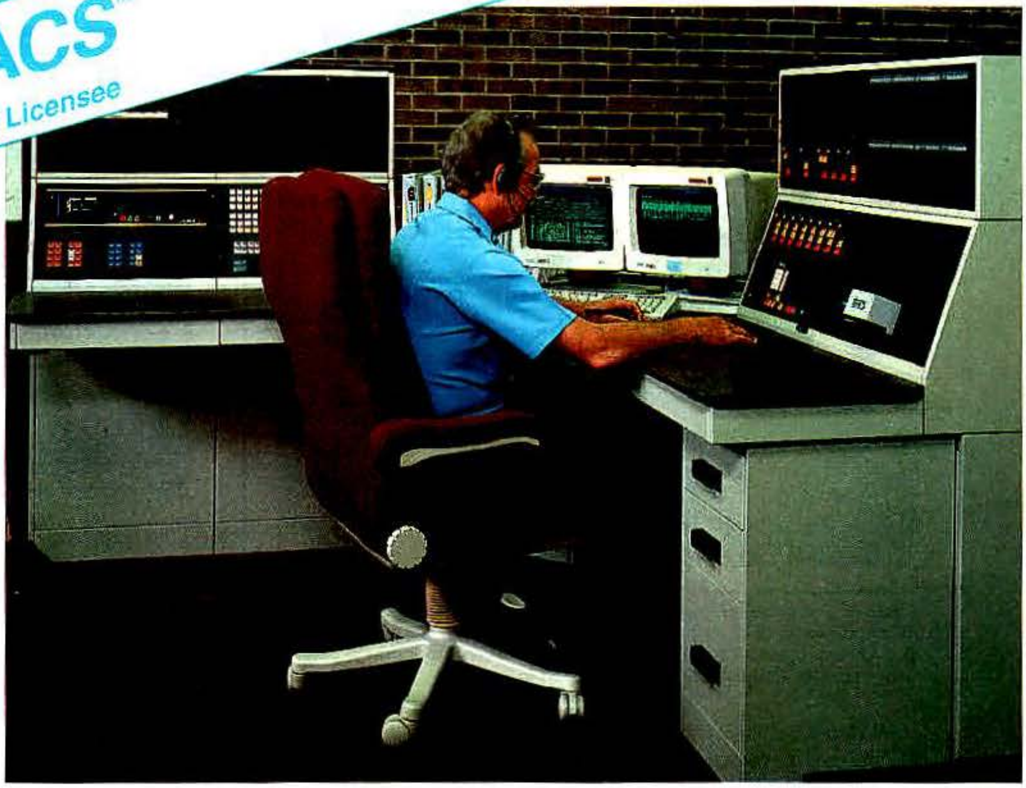

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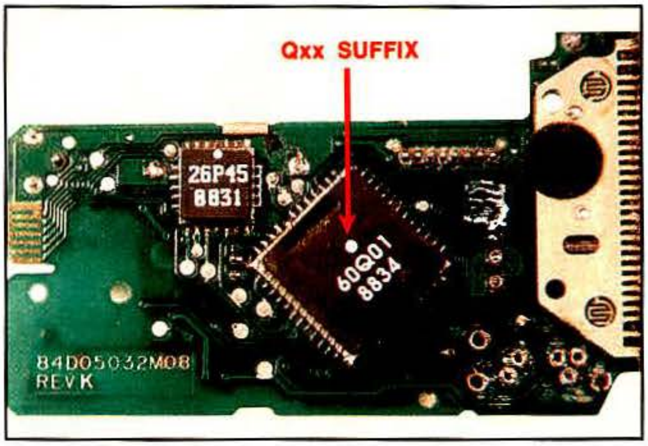


Photo 1. The suffix of the identification number printed on the decoder microprocessor is known as the *Qxx* suffix because it includes the letter *Q* and two digits. The suffix indicates the microprocessor's paging 'language' (POCSAG or Golay) and speed.

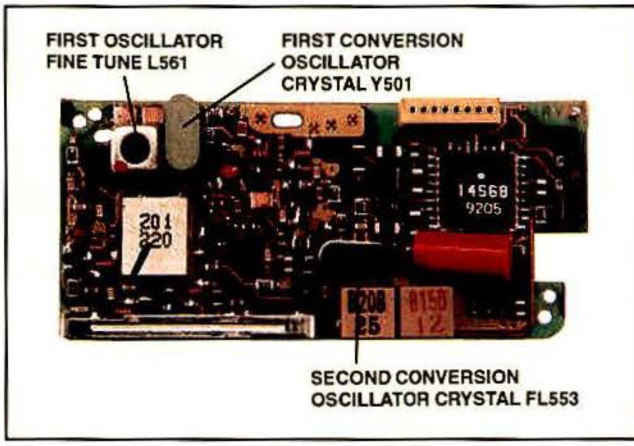


Photo 2. A view of the NRF4071E 928MHz–932MHz receiver board with a 17.9MHz IF shows the locations of the first conversion oscillator crystal, second conversion oscillator crystal and fine-tuning inductor L561.

With a small screwdriver placed at the "L" formed by the circuit board (to the left of the positive battery spring) and while lifting the lever of the side-mounted *on-vibrate-beep* switch, gently wedge the entire unit from the case. (See Figure 1 on page 22.)

Turn the circuit boards over to read the *Qxx* number on the microprocessor. (See Photo 1 above.) Let's call it *Q07* for our discussion, so (from our *frequency and format chart* in Part 3) the pager should operate with POCSAG at a rate of 1,200bps.

Gently rock the 8-pin junction, separating the two boards. With a small screwdriver, move the boot around the first conversion oscillator crystal. (See Photo 2 above.) Unless your eyes are good, I suggest the use of a 10-power (10X) loupe (magnifying lens) as an aid in reading the frequency information from the crystal.

Often, the crystal is installed backward, with the frequency information facing the fine-tuning inductor housing. In this case, note the characteristics of the antenna and the preselector tuning networks.

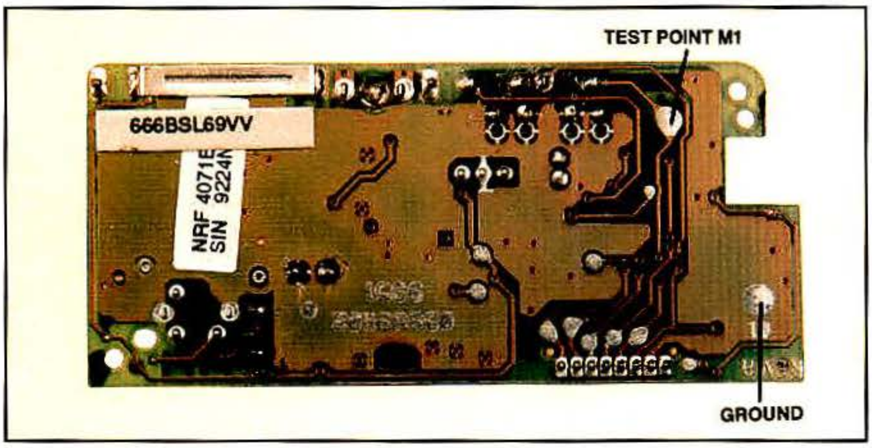


Photo 3. Adjust the RTL-1005 test fixture's probes across the receiver board's test point M1 and ground.

Having determined the range of receiver frequencies, change the crystal to match the desired frequency provided by the airtime carrier. The *frequency and format chart* for your own area will tell whether the capcode can be programmed to operate on POCSAG at 1,200bps for any given radio frequency.

From the *F&F* chart given as an example in Part 3 and assuming a 930MHz pager, paging systems on 929.6625 MHz, 929.7125MHz, 931.2875MHz, 931.4875MHz, and 931.6875MHz all use POCSAG at 1,200bps. Experience in Houston has shown transmitter problems with 929.7125MHz and transmitter loading on 931.6875MHz. I might choose 931.2875MHz because the frequency is not heavily loaded—*yet*.

Determining the first conversion oscillator frequency requires a knowledge of the first intermediate frequency. Subtract either 17.9MHz or 45.0MHz from the operating frequency.

Let's say the first IF frequency is 17.9MHz; therefore

$$931.2875 - 17.9 = 913.3875$$

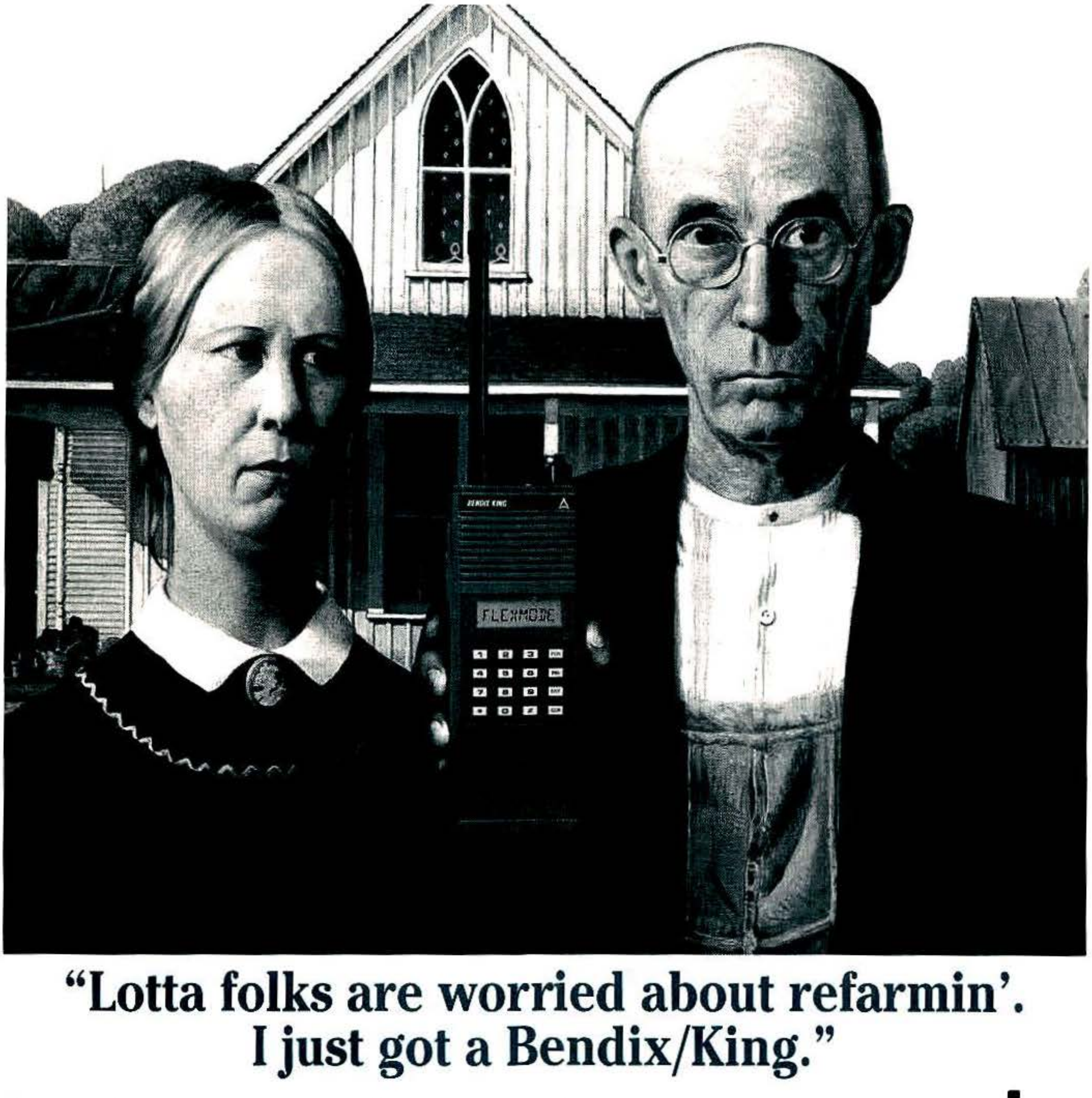
This value (913.3875) is divided by 12 to obtain the first conversion oscillator frequency:

$$913.3875 \div 12 = 76.115625$$

Remove the original first conversion crystal and install a 76.115625MHz crystal in its place. Trim the crystal leads and reassemble the pager, leaving the back cover off.

Place the pager in the *service mode* with the word *paging* displayed on the LCD. Place the unit in the RTL-1005 test fixture (with the IFFER attached), and bring down the probes to M1 and ground. (See Photo 3 above.)

Radiate a fairly strong (>500μV) signal at 931.2875MHz with a 4.5kHz-deviated 1kHz tone. Adjust the fine tuning inductor slug with a ceramic tuning tool until the



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signal from IFFER approximates a sine wave.

If you are in shielded room, such as the one described in Part 1 of this series, you can adjust the pager for maximum sensitivity. As a final check, use the oscilloscope attached to the IFFER and the IFFER's loudspeaker to watch and listen to the activity on 931.2875MHz. While the paging transmitter is active, the difference between the strength of its signal and the signal generator's signal may be on the order of only 10dB.

To this point, you have a working receiver at 931.2875MHz, but the decoder is still untested.

Remove the pager from the radiation test fixture. Depress the gray button to reveal the current capcode in the pager. Set the POCSAG-Golay generator to match the original capcode.

Depress the gray button on the Bravo to show *paging* on the LCD and set the pager back into the radiation test fixture. First defeat the 1kHz tone on the RF signal generator. Then modulate a strong RF signal with the code generator. A single *beep* and a flash of the back-light lamp indicate a working decoder.

Continue to decrease the RF signal while activating the code generator. At a certain point, the pager no longer will respond. In an unshielded room (with pager transmitters active) the pager will have a lot of junk data with which to contend.

Only with a shielded room will an accurate measure of overall sensitivity be obtained.

Okay, the pager understands the old capcode, and the receiver is working. It's time to go to the programmer.

Bravo programmer

Place the pager into the programmer.

When the programmer is turned on, it plays about 10 seconds worth of commercial messages. Then, it asks the operator to select:

1 GSC (Golay sequential code) or
2 POCSAG

Because you want POCSAG for this pager, select *2*. The screen now displays:

1 JRB/JRC
2 BAB

BAB, JRB and JRC were parts of the original model numbers, and probably have been lost as labels were replaced.

Placing the Bravo pager in *Test Mode 1*

1. With the pager off, depress both push-buttons beneath the display and bring slide-switch fully up (to *beep position*).
2. A steady tone at 3kHz or higher will be heard.
3. Release both buttons and momentarily depress the gray (*read*) button. The word *paging* (with an optional suffix in some cases) will appear.
4. At this point, the Bravo pager is configured as a full-time receiver. If it should receive its capcode, one lamp will flash and a single beep will be heard from the internal speaker.

Reading the capcode

1. Perform steps 1 through 3 above.
2. Depress the gray (*read*) button several times until the capcode is displayed on the LCD.

Pager servicing series

Part 1: "Build a Shielded Room," January 1994.
Part 2: "Build An 'IFFER'," February 1994.
Part 3: "Frequencies, Coding Formats," March 1994.
Part 4: "From Bench To Programmer," April 1994.

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Simply put, JRB/JRC is normal POCSAG code, whereas BAB responds to inverted POCSAG code. Select *1*.

The screen now presents several options. Because we want to program the Bravo, we select option *2*.

The screen now displays ENTER 7 DIGIT CAPCODE.

Select one of the capcodes for 931.2875MHz POCSAG at 1,200bps and enter the capcode. Hit the ENTER key.

The following screens allow a Bravo pager to perform numerous functions and are found in the programming manual which comes with the Bravo Programmer.

After the customizing, the programmer prompts, READY TO PROGRAM? Punch YES.

Any erratic connection between the pager and programmer halts the programming and prompts INSERT PAGER. Some wiggling and wedging might be needed to make proper connection.

The programmer will report PROGRAMMING PAGER and PROGRAMMING FINISHED. Remove the pager, grab your notes, and head for a telephone.

On a Touch-Tone telephone, dial the phone number associated with the capcode you have programmed. Depending on the activity on 931.2875MHz, the pager should sound off in a few minutes. Assuming success, strike out the capcode from your list. This step prevents duplicated pagers and upset customers.

Acknowledgement

I would like to thank J.H. Kim, owner of JJ Sounds, South Houston, TX, and co-workers Raymond, Tim and Pete, for their help with this project.

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Sonoma County center adopts touchscreen dispatch control

New technologies expand emergency communications services for police, fire, emergency medical and other county agencies. Demonstrations and training boost dispatchers' acceptance of the new system.

By Joseph M. Perez

Although Sonoma County, CA, is a rural area characterized by mountainous terrain and 67 miles of rugged coastline, it is home for more than 400,000 people.

The Sonoma County Center in Santa Rosa houses the county's Emergency Operations Center and the Sheriff's Dispatch Center. The dispatch center is responsible for handling 9-1-1 calls, public safety traffic and other requests for aid. The dispatch center also coordinates responses from fire departments, medical units, the California Law Enforcement Mutual Aid Radio System (CLEMARS) and several county agencies. The center either monitors or conducts two-way communications on more than 50 radio channels with more than 1,000 users.

Since 1985, the dispatch center had used a microprocessor-based cathode-ray tube (CRT) display system with push-button operation. The enclosures were metal racks that could not readily accommodate computer-aided dispatch (CAD) hardware. Moreover, the racks did not comply with federal Americans with Disabilities Act (ADA) accessability requirements and did not address ergonomic issues.

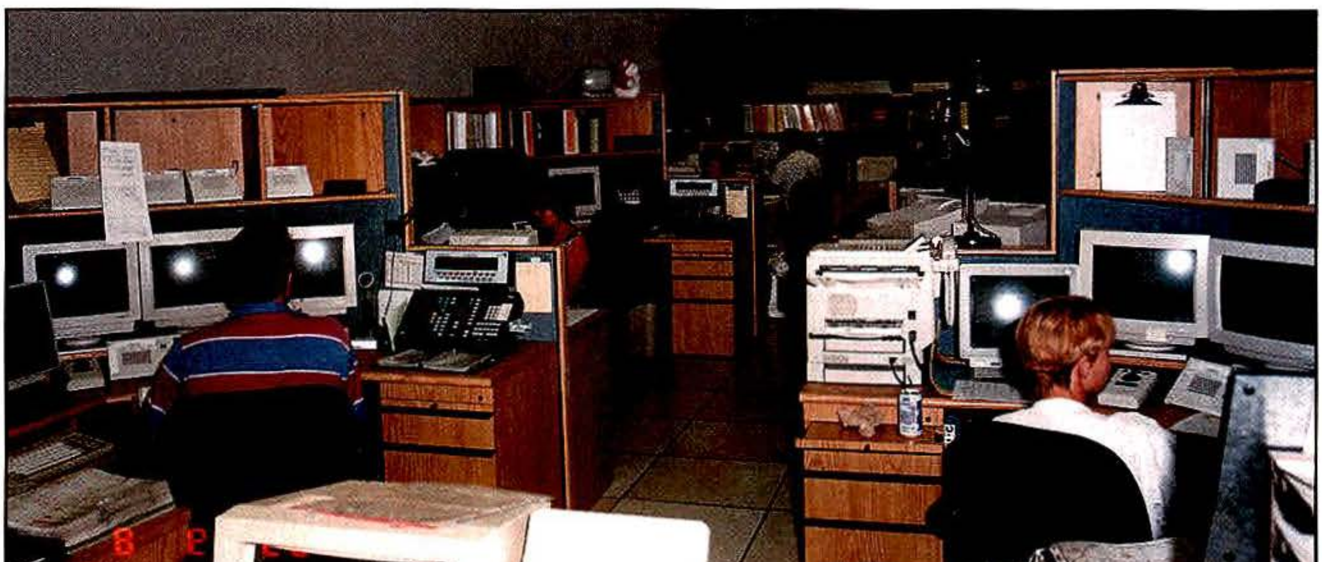
The new dispatch system installation was necessary to integrate the radio console and CAD system to use space more efficiently and to provide additional dispatch services requested by other agencies.

A number of vendors were sent a request for proposal (RFP) that included the possibility of a video-based system. Although the staff initially considered a mixture of push-button and video technologies, the decision was made to use full video technology.

A review of vendor responses and an ergonomic and space evaluation led to the selection of a video-based system as the most versatile and cost-effective solution.

The dispatch center management's criteria included a flexible system, cost-effective equipment and the capability to serve a growing community despite shrinking budgets — without additional employees. This desire is typical among financially strapped local governments. Equally important was the acceptance of the system's capabilities by dispatch center employees. Managers and supervisors

Perez is the Sonoma County, CA, General Services Communications Division's assistant communications manager for radio. He is also project manager for the installation of the Ultra-Com PRO touch-based dispatch system supplied by Modular Communications Systems, North Hollywood, CA.



The Sonoma County (CA) Communications Division, with 11 operating positions, houses the Emergency Operations Center and the Sheriff's Dispatch Center.

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The Ultra-Com PRO dispatch system is based on the 80386 and 80486 ("386/486") microcomputer chip PC, supported by Intel's 16-bit microcontroller. The system incorporates IBM touchscreen technology, in addition to a mouse or trackball.

spent much time with each dispatcher to be certain that the system met dispatchers' operational and ergonomic requirements.

The decision to use modular rather than traditional metal rack furnishings was also pivotal in fulfilling the existing facility's space and ergonomic requirements. For example, the new system had to be installed in the same room where 9-1-1 services were dispatched. This necessity required cooperation among architectural, technical and operational staff members during a short installation period with intensive activity.

About 30% more dispatch positions and a training position were created, and CAD was incorporated. These improvements were made possible, to a large degree, by the PC-based, touchscreen technology's compact design.

The new system allows the user to change and modify software to accommodate operational requirements. The flexible software, which uses off-the-shelf database technology, is more satisfactory and "user friendly" compared to other video-based systems considered for the dispatch center.

The dispatch system is based on 80486

("486") microcomputer chip PC technology, supported by Intel's 16-bit 8097 microcontroller. Independent microcontrollers make it possible for individual workstations to operate independently.

Because the users can configure the software, less assistance is required from the supplier to improve efficacy in the operating environment for dispatchers and technicians. That advantage improved their acceptance of the system.

Initially, the dispatch staff was less than enthusiastic about the prospect of using touchscreen technology as the sole means of accessing the radio system; nonetheless, after a demonstration of the technology, the staff and management had a greater appreciation of the flexibility and growth potential.

The IBM touchscreen technology is significantly better than any other system we evaluated. Its precision and ability to be operated by any source of *z axis* pressure makes it a very practical system. Z is the axis from the operator to the screen, and it involves the pressure the operator must apply to the touchscreen.

The system also provides a trackball for data entry in lieu of touchscreens, depending on user preference.

Specialized software allows the user to modify screens to meet specific operating requirements.

The dispatch center is integrated with the county's radio and microwave equipment, an 11-site, 4-channel, simulcast UHF radio system with sophisticated receiver voting and interfaces to which CAD was added. The 11 operating positions are used as follows:

☐ 3 positions: sheriff dispatch.

☐ 2 positions: fire dispatch, unincorporated areas.

☐ 1 position: emergency medical


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service and ambulance dispatch.

☐ 1 position: supervisory.

☐ 1 position: 9-1-1 "call-taker."

☐ 1 position: training.

☐ 1 position: main equipment room maintenance.

☐ 1 position: off-premises, remote system monitoring.

The training program started by familiarizing employees with screens developed on a demonstration PC in the dispatch center. Dispatchers used this system to see results of their efforts off-line, and it was used to fine-tune screen designs based on their comments.

The communications division's technical staff hopes to emulate the console software on laptop PCs. This emulation will enable technicians to troubleshoot problems remotely, reducing the number of after-hours trouble calls.

After demonstrating specific test screens, Steve Simpkin, an engineer with Modular Communication Systems, conducted training sessions and familiarized the staff with the system's unique features.

Additional technical training was provided to the technical staff to facilitate ongoing maintenance. This training included how to program operational changes that could be implemented with the PC-based software.

Previously, many manual functions were required to tune the multiple-channel medical base radios to set up medical patches (duplex telephone interconnections) so doctors on the telephone could speak with emergency medical staff via their radios and transmit "vital sign" telemetry on the same radio channel.

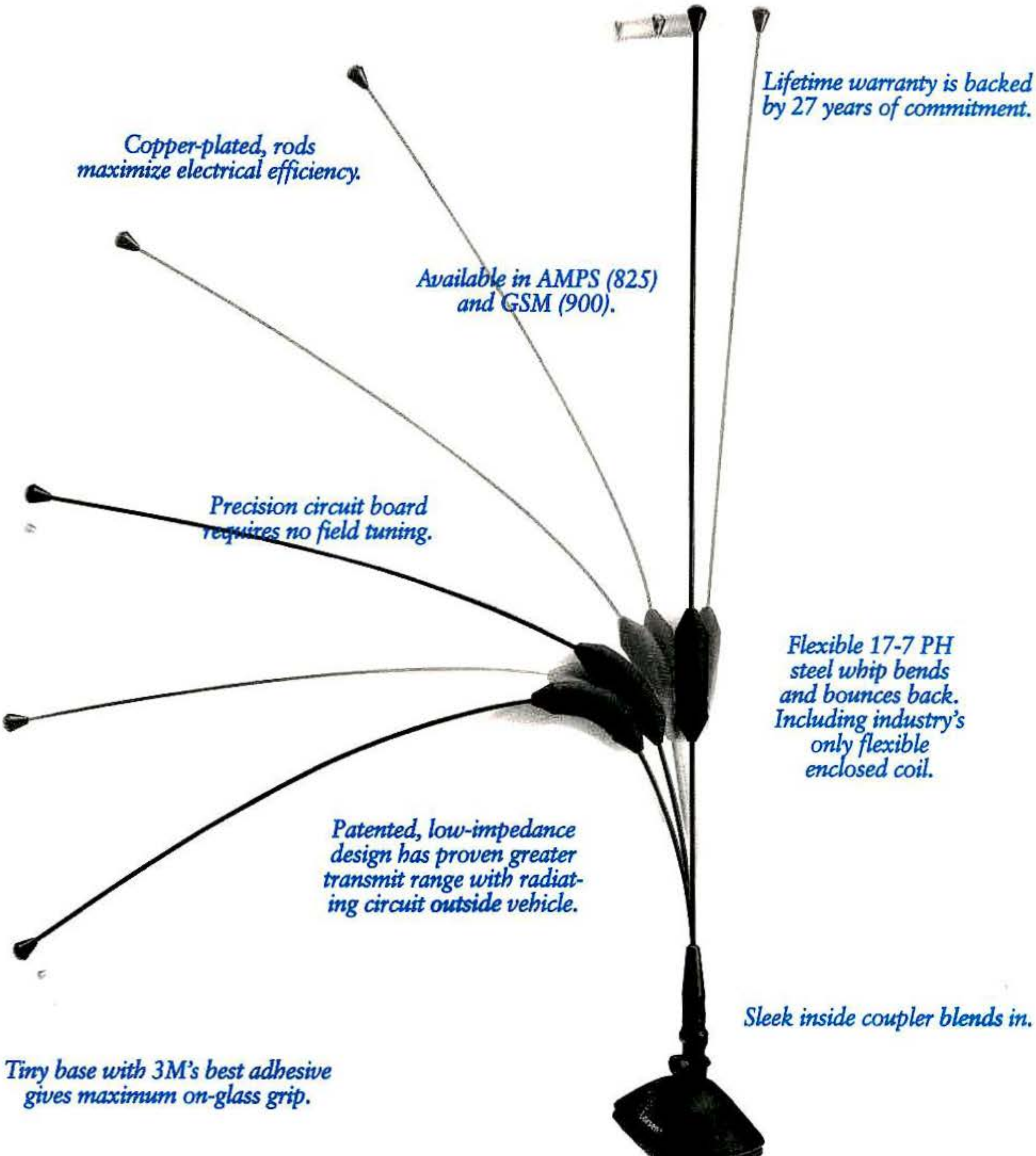
The training program started by familiarizing employees with screens developed on a demonstration PC in the dispatch center.

These functions were automated into *macros*, so that pushing a single button would activate a complex series of commands. Macros are files that represent a series of keystrokes, eliminating the need to enter all of the keystrokes that otherwise would be necessary to perform a predetermined function. Additional dispatch staff training was required to implement these changes, which substantially expedite setting up EMS dispatching functions.

The new system was installed by the communications division's three-person technical staff, which is also responsible for maintaining a dozen remote radio sites and more than 2,000 mobile, hand-held and mountain-top radios. Only because of the relative ease of installation of the system was the effort manageable.

The technical staff's previous experience with PC technology was minimal. Because it was apparent that this technology was destined to control all aspects of their public safety communications hardware, the technical staff exhibited a high level of interest in learning about it.

Their success in learning the system has been exemplary, and it can be attributed in large measure to the software's "user-friendliness."



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Use protective clothing for safety in RF fields

Complying with the new FCC regulations about RF hazards is made easy with protective clothing that shields the wearer from RF energy. Employer liability always has been an issue; now a standard must be met.

By Joseph A. Amato

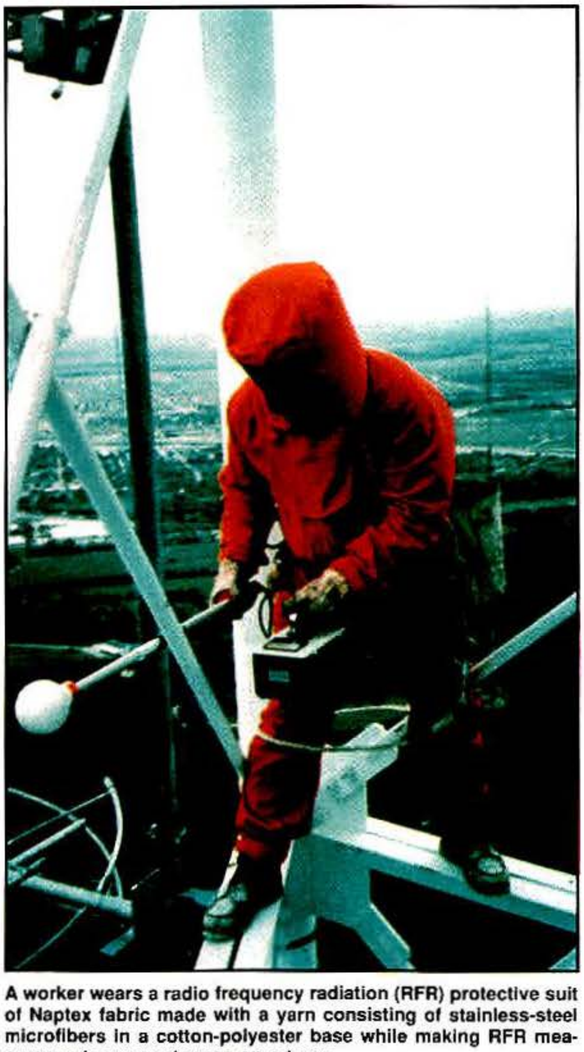
FCC licensees offering two-way radio, paging and cellular services that were exempt from RF hazard regulations soon may have to comply with the new ANSI/IEEE C95.1-1992 Standard.

Compliance will be required if new rules are adopted according to an FCC *Notice of Proposed Rulemaking, Gen. Docket 93-62*, in the "Matter of Guidelines for Evaluating the Environmental Effects of Radio Frequency Radiation."

Until now, there has been little or no concern about the RF hazard at base station sites on towers and rooftops. Any apparent concern usually involved broadcasters. The FCC also used to specifically exclude cellular facilities from certifying compliance with RF environmental impact rules.

A broadcast station is now responsible for the safety of any person in the vicinity of its transmitter. Regulations oblige the station to ensure that no one is exposed to radiation levels exceeding the ANSI standard.

When broadcast stations share a site, they all must cooperate in the matter of RF safety. The required procedure has been to reduce (or to turn off) transmitter power output to as many antennas as necessary to eliminate the RF hazard where work is being performed. Unfortunately, this procedure may not be followed when it affects station revenue.



A worker wears a radio frequency radiation (RFR) protective suit of Naptex fabric made with a yarn consisting of stainless-steel microfibers in a cotton-polyester base while making RFR measurements near antennas on a tower.

Communications transmitter owners may be reluctant to reduce power or shut down for the same reason as broadcasters.

In addition, it may be difficult to obtain the cooperation of multiple licensees for a rooftop or tower full of paging antennas, two-way radio antennas and cellular antennas to cut power during maintenance work.

Beyond FCC rule compliance is the issue of Occupational Safety and Health Administration (OSHA) regulations and an employer's responsibility to protect workers from an RF hazard, no matter who owns the transmitters. A way is needed to continue uninterrupted telecommunications service and to protect individuals working on or near the site.

Try this on for size

RF protective clothing (RFPC) provides an answer. (See Photo 1 to the left.)

Some protective clothing has reached the market without gaining enough recognition and acceptance to be used widely because of various drawbacks.

Naptex material (developed by NSP, Nordendorf, Germany) meets the pertinent RFPC requirements. Among these requirements are the material's comfort, durability, maintainability, effectiveness and ability to withstand inordinately high RF fields.

Protective clothing should be just that: clothing. It should be as comfortable as possible and able to withstand the rigors of regular machine laundering. Tests on preliminary clothing materials showed that, although they were fairly comfortable, they did not hold up well after repeated washing and drying. Most samples lost an average of 3dB-6dB of attenuation after a

Amato is RF radiation safety consultant at Maxwell Safety Products, Smithtown, NY. The company offers the RF protective clothing described in this article.

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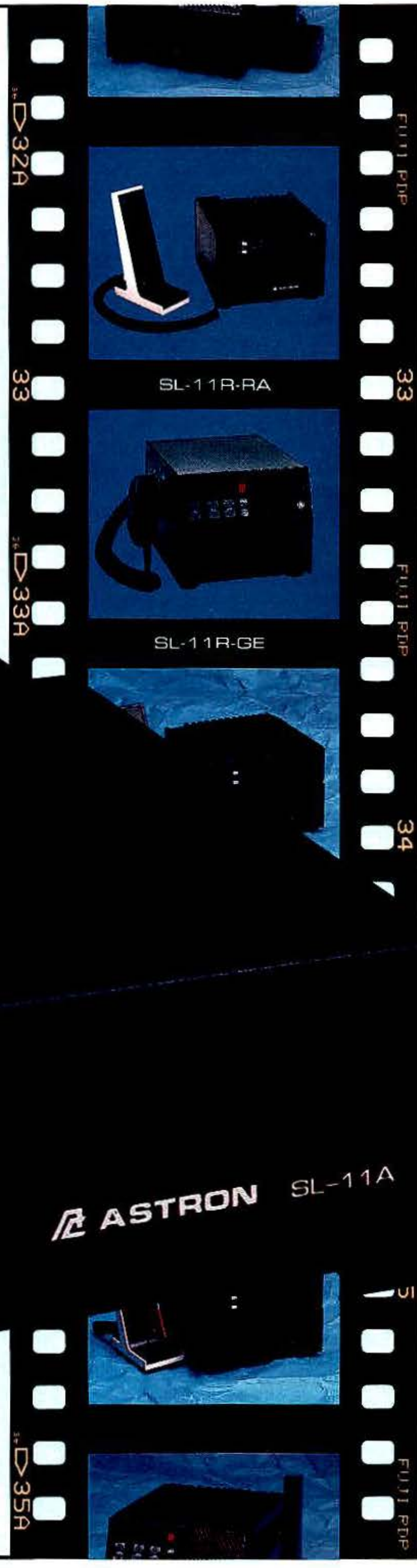

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number of launderings.

The previous method of making RF protective material integrates metallic fibers within a textile. Material made in this way cannot handle high levels of RF energy without being destroyed.

Naptex material uses a patented process that coaxially encapsulates stainless-steel and polyester microfibers along the length of a cotton-wrapped yarn. This produces a yarn virtually free of fiber protrusions.

At the FCC's request, OSHA reviewed data from exclusive tests performed by the Naval Aerospace Medical Research Laboratory (NAMRL). OSHA determined that Naptex meets its requirements for reliable and effective RF protective clothing. Although it is OSHA policy neither to endorse nor to approve any product, this open acknowledgment and recognition supports the manufacturer's claims.

Protective clothing is not designed to allow a technician to handle energized elements or hot conductors. It is designed to allow a technician to work near operating RF systems. For example, on a cellular monopole there are likely to be three or more sector antenna panels. When one is shut down for repair, the others may remain in

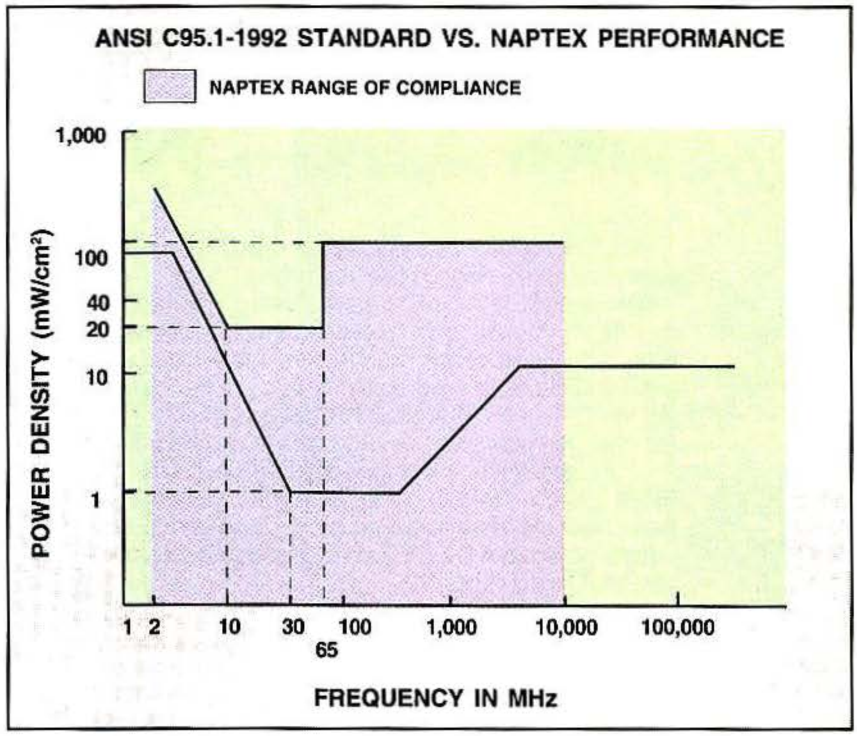


Figure 1. This figure represents the protection offered by Naptex RF protective clothing against RF levels as high as 125mW/cm²

full operation, subjecting a technician to a potential overexposure to RF radiation. Similarly, maintenance workers making repairs on a rooftop, or replacing a lamp on a tower with multiple antennas, may be exposed to an RF hazard.

Technical Aspects

The U.S. Air Force, taking an interest in protective material for use in high RF fields, has been conducting tests on Naptex material to determine its exact threshold. So far, levels exceeding 125mW/cm² at frequencies above 2GHz and levels exceeding 300mW/cm² at frequencies below 1GHz have produced no adverse effects. A NAMRL analysis shows that a level of 15 *watts*/cm² must be reached to heat the material to the failure point.

The consensus among most consultants is that, even on broadcast towers, the highest RF levels encountered are generally from 50 *milliwatts*/cm² to 75mW/cm² at the closest practical proximity to any particular radiator or cluster of radiators. On rooftops, though, a paging or two-way radio antenna can exceed this level, mainly because an individual may come within inches of it. The protective clothing's efficiency must be supported by an ability to withstand high RF levels. The maximum fields, or equivalent power densities, at which Naptex material complies with the ANSI C95.1-1992 standard are 20mW/cm² from 10MHz to 65MHz and 125mW/cm² from 65MHz to 10GHz. (See Figure 1 on page 42.) The reason for different levels at these frequencies is not because of the material's limitations, but because of *resonance*. The adult human body is resonant between 30MHz and 60MHz.

The ANSI standard takes this resonance into consideration and specifies a strict 1mW/cm² limit from 30MHz to 300MHz. By offering protection against levels as high as 20mW/cm², the RF clothing provides protection to a level that is 20 times the standard.

The principle of resonance implies that the body becomes an RF conductor; therefore, an induced current flows through the body and into the ground below the feet. This condition is a constant problem among RF heatsealing equipment operators and broadcast tower crews.

Protective clothing solves this problem with overshoes and gloves that must be worn where RF fields below 300MHz are present. The overshoes are designed to provide the necessary protection without impairing the user's climbing ability.

A real solution

Protective clothing costs little compared to revenue that may be lost if RF power must be reduced or turned off during maintenance. There are also savings in avoiding FCC or OSHA fines for noncompliance or the cost of employee health care claims.

Many RF suits are in use in the United States, Europe and other parts of the world. The applications range from broadcasting and telecommunications to automotive electromagnetic compatibility (EMC) testing and military base operations.

The RF compliance issue will become more prevalent and widely regarded by health and safety officials worldwide because of public awareness and a public demand for answers. Management must address the issue when it requires employees to work in RF fields.

The pending FCC regulation will accentuate concern among workers, who will want every means available to protect themselves from RF hazards.

IVHS: Design and conquer

Intelligent Vehicle Highway System (IVHS) benefits will be realized long before the 'auto-auto' is developed, if ever, for public use, and the advances already coming forth will make highways safer and more efficient.

By Robert H. Schwaninger Jr.

Imagine a commute with automobiles moving rapidly around a city's highways, all controlled by a central computer system that routes each car to its driver's preselected destination. Meanwhile, the driver reads a morning paper in comfort and listens to the radio while sipping coffee, waiting for the system to send a digitized signal to the control port, indicating which exit the vehicle will be directed toward. Sound fantastic? It is.

When the uninformed hear about Intelligent Vehicle Highway Systems (IVHS), this scenario is the one that often jumps to mind.* This quantum leap in imagination is both titillating and unfortunate. Remember when some people believed that the advent of paging systems eventually would lead to the creation of "Dick Tracy"-style two-way wrist radios? When that did not happen right away, part of the potential market was so disappointed that it ignored other beneficial products that evolved from paging technology.

Similarly, some people will be blind to other IVHS benefits if they do not see early development of the automatic vehicle control that they perceive IVHS to be.

The enormous efforts in IVHS development are not in vain. The public will enjoy numerous benefits from the ever-evolving technology long before the "auto-auto" is a reality. Some of these benefits exist in today's marketplace, and the FCC and the Department of Transportation (DOT) are pressing to bring more to the market quickly. As usual, the Department of Defense (DOD) is also casting its lot with the newest advances.

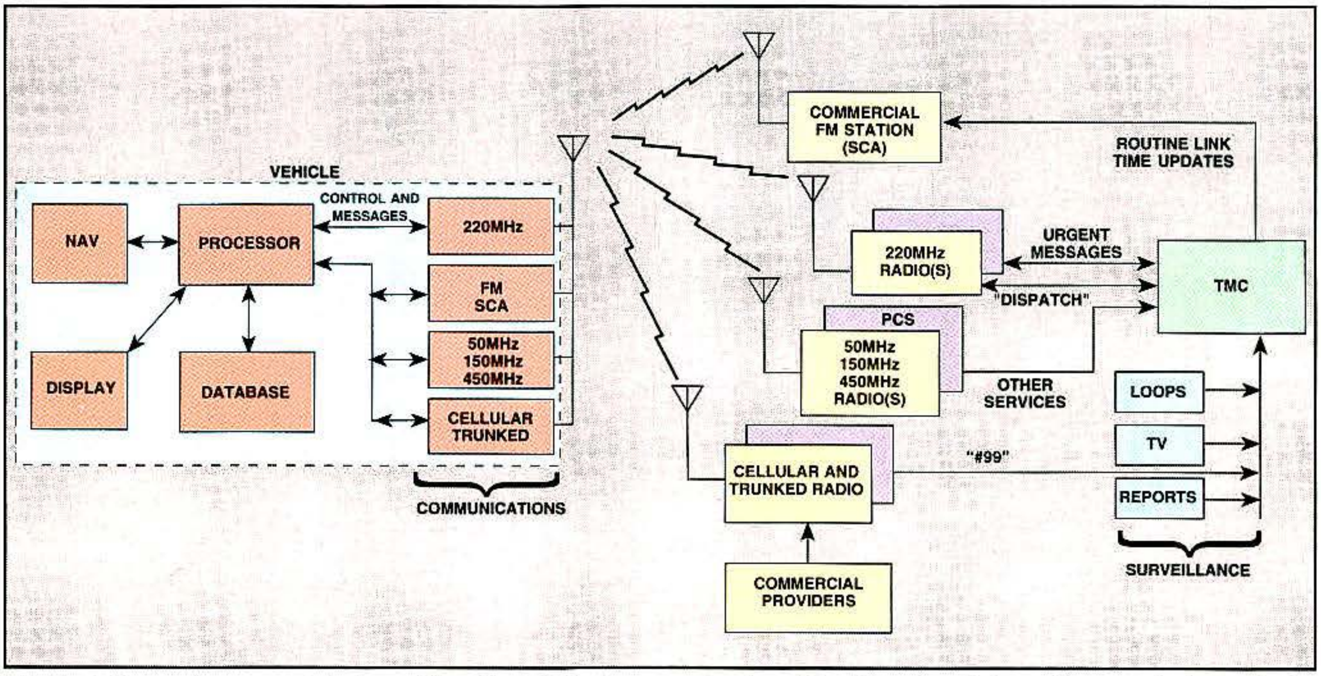
A review of what is included on the promoters' wish lists provides a better idea of what IVHS is today and what it soon might become. You can see the hurdles that remain and how likely each IVHS service is to come to the market.

Electronic toll and traffic management

Although IVHS is intended to create a ubiquitous communications system covering all of the country's highways and roads, the nation's tollways, bridges and tunnels provide a microcosm for development. The traffic is more controlled, and a

Schwaninger, *MRT's* regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington, DC, and a member of the Radio Club of America.

*In fact, this misconception has been perpetuated since the 1939 New York World's Fair, where General Motors' Futurama exhibit predicted a system where speed and spacing of vehicles on the highway would be electronically automated by 1960.



This block diagram shows an early implementation of an intelligent vehicle highway system (IVHS) service that offers navigation assistance and road condition information. Various radio communications technologies support the system.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central, pervasive authority often monitors operations and problems directly.

That central authority often is progressive and well-funded, creating a favorable atmosphere for new technology. One such technology is rapid toll collection with electronic toll and traffic management (ETTM) systems that record vehicles as they pass through a toll plaza and collect fees for the vehicle via RF data communications links.

ETTM systems are seen as a remedy to toll plaza congestion created by long queues of vehicles waiting to pony up at the booths. The obvious efficiencies are expected to save employee time, transaction costs and a myriad of other costs associated with the tollway operation.

Unfortunately, many ETTM systems in place or under consideration operate in the 902MHz-928MHz band. This band is becoming increasingly congested with cordless phones, high-powered amateur radio facilities, federal government users, spread-spectrum equipment and a plethora of other devices that have begun using the band during the past five years.

ETTM systems rely on low-powered, unlicensed tags or reflectors mounted on the vehicle and signals emitted at levels below 250μV/m at 3 meters. The systems are highly vulnerable to radio interference from competing, co-channel systems. It is unlikely that ETTM will survive the introduction of location monitoring systems (LMS) in the same band, and the ETTM systems probably will migrate to the 2.45GHz or 5.8GHz band.

Location monitoring systems

Some of the largest system operators and developers are attempting to bring a new IVHS service to the market called *location monitoring systems.* These systems will provide a tracking service for all associated vehicles, and some of the systems will pass along other data and messages. LMS is intended to provide intraurban fleet management services, auto security for tracking of stolen vehicles, and ancillary services such as fleet messaging.

The Notice of Proposed Rule Making before the FCC that suggests using the 902MHz-928MHz band for LMS met resistance from entities with devices that would be rendered useless or highly impaired by wide-band LMS systems operated at numerous locations in a given area. For example, cordless phones might be affected, and, as previously mentioned, ETTM systems would suffer in such a shared environment. Most spread-spectrum devices use this band, and there is no plan for sharing the band with amateur operators in a way that would prevent interference from amateur stations.

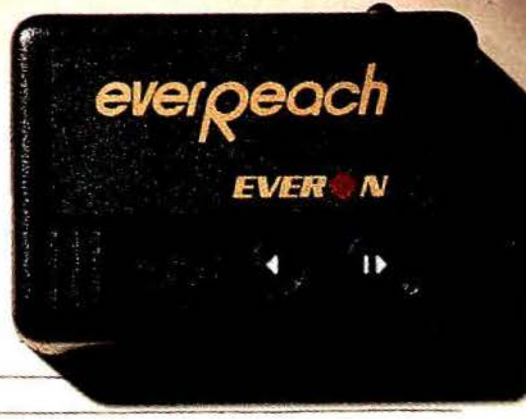
Despite the wrangling over potential spectrum uses, LMS systems are a promising addition to IVHS. Assuming that the FCC promotes compromises among LMS operators and the rest of the band's occupants, LMS will provide the first dedicated RF link for managing vehicles in a given area using the newest digital technology for high-speed data transmission.

Roadside commercial safety systems

IVHS foreshadows eliminating or reducing the need for weigh stations. Systems are being designed to make electronic tests of commercial vehicles to determine whether the vehicle's weight and brake condition comply with state regulations. Instead of stopping at the weigh station, trucks would receive "electronic credentials" to pass through a jurisdiction.

The state would collect its revenue and

RESUME



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protect the use of its highways with fewer employees. The added benefit of improved highway safety through electronically monitored vehicles is quite appealing.

The problems in designing such a system, including rugged onboard equipment, have been daunting. Many have tried, but few have succeeded, because accurately determining the weight of a vehicle moving at 55 miles per hour is not easy (not to mention the other safety tests that designers would like to include).

Still, the industry perseveres. Designers look for answers, urged on by a trucking industry that wants to speed deliveries and by public officials who want increased efficiencies.

Add to the other design headaches the choice of RF spectrum for these systems, and the complexity is magnified. As with ETTM, roadside commercial safety systems will use low-powered, onboard equipment that might be highly susceptible to a crowded RF environment. These are expected to use the 2.45GHz or 5.8GHz band.

Mayday systems

"Mayday systems" are intended to alert public safety officials immediately when an accident or a breakdown occurs. One message might be sent if the engine stops en route, another if the airbag were inflated.

Mayday systems would enable public safety officials to respond more quickly, and a faster response to an accident might save lives. Also, the faster the response, the sooner the roadway is cleared for better traffic flow.

These systems may be an adjunct to LMS operations; therefore, spectrum might be assigned simply by allowing LMS operators to offer this service as an extra feature. On the other hand, mayday systems might be considered too sensitive and the potential liability too great to allow private companies to operate them. If so, additional spectrum will be necessary to bring this service to the market.

En route travel advisory

Another possible IVHS system would allow a motorist to view a display mounted in the car for current navigational information. Such a display might tell the driver about road hazards and alternative routes, helping the motorist to choose the best way to a destination under current conditions.

Despite its obvious usefulness, en route travel advisory system design problems are, once again, daunting. The systems require high-speed data transmission personalized to each traveler's needs. For example, two cars traveling in parallel usually have different destinations, so different data would be required to respond to each traveler's needs. The data storage, reception and retrieval capacity would have to be enormous, particularly if the system is to provide real-time information about traffic and road conditions.

The system would be interactive; therefore, it would require a large two-way communications capacity. A large configuration of receivers and monitors would be required, and data processing, including transmission time, would have to be extremely rapid.

Fleet management systems

The IVHS umbrella includes certain Global Positioning System (GPS) applications. GPS uses a constellation of earth-orbiting satellites to compute receiver locations on the earth or in the air. The possibility of monitoring nationwide fleets of trucks and railcars has held great interest

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The COM-120A

for GPS application developers.

Mobile satellite service proponents have long claimed that a large market exists to coordinate the delivery of goods by highway and rail with a combination of a little messaging service, a little dispatch service and a dash of radiolocation—and they may be correct.

What has stood in the way is money.

As first proposed, these services were to use dedicated satellites, an extremely expensive undertaking. The cost of development, launch and system design crippled Geostar and has slowed other ventures. The market was not willing to bear the construction cost.

Adding to the construction cost was the cost of onboard vehicular equipment. Early estimates were about $500 per unit, with later models using Loran C estimated to be cheaper at about $175. Multiply that by the number of railcars to be outfitted, add the cost of monthly service to offset design and construction costs, and soon it becomes apparent why these systems are not yet widely used.

Yet, GPS for fleet management is making a comeback thanks to new system designs and marketing. First, there appears to be a greater supply of cost-effective transponder capacity on existing satellites. Second, system marketing is changing. Many companies no longer shoot for a nationwide contract. Instead, they are opting to provide fleet management in smaller regions through enhanced GPS services to a discreet number of vehicles in a limited territory. Such systems are more cost-effective and may be designed using present technology.

Current technologies have improved sufficiently to make real-time positioning of aircraft possible. GPS is used in connection with crop-dusting operations over tens of thousands of acres. West Texas cotton growers have used GPS by itself to assist them in spraying fields to prevent boll weevil infestation.

The future for greater use of GPS for fleet management remains quite promising, and its inclusion in future IVHS system architecture is a foregone conclusion. Still, operators and users must bring their expectations down to earth.

The maze to market

From concept to consumer, the road to market for IVHS services winds over regulatory bumps and around competitive terrain. Questions facing system designers might include:

- ☐ Is the technology available?
- ☐ Is the spectrum available?
- ☐ Is there a market?
- ☐ Who will provide the service?
- ☐ Who will finance system design and construction?
- ☐ Can the cost of end-user equipment be made reasonable?
- ☐ How much competition will I face, and from where?

Considering the research and development necessary to bring these products and services to market, the delay in meeting each of these above criteria is quite understandable. Even after all of the questions are answered to a producer's satisfaction, the question of regulation looms in the background. The FCC and the DOT must decide each system's worth and the amount of public resources and radio spectrum to be devoted to delivering that system.

IVHS system promoters are struggling to find radio spectrum for their devices and services. Suggested solutions include using TV station vertical blanking intervals (VBIs); FM broadcast subcarrier frequencies; devoted cellular and, later,

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personal communications services (PCS) channels; VHF and UHF spectrum that might become available through refarming; the 902MHz-928MHz bands presently under consideration for LMS operations; the 2.45 or 5.8GHz band for ETTM systems and other roadside data transfer systems; the 220MHz trunked systems that are slowly being constructed; and specialized mobile radio (SMR) systems.

Each spectrum alternative carries advantages and disadvantages. Propagation characteristics and system construction cost must be considered. The uncertainty of the 220MHz market and the questions surrounding use of the 902MHz-928MHz band remain unresolved. VBI and subcarrier frequencies may not always be satisfactory for covering a wide area with varying terrain. The results of spectrum refarming below 512MHz remain unsettled.

The one technology that appears to be ready to provide necessary spectrum, distribution and digital capacity is enhanced specialized mobile radio (ESMR). ESMR systems will have regional coverage. The number of existing facilities awaiting conversion is quite impressive. Much spectrum was underutilized with analog modulation, and switching to digital modulation should provide the necessary capacity. Many ESMR operators are establishing cooperative relationships with local dealers to create distribution networks.

From concept to consumer, the road to market for IVHS services winds over regulatory bumps and around competitive terrain.

Most important, from the standpoint of public policy, ESMR systems are likely to employ certain standardized equipment and protocols, thereby enhancing equipment and spectrum compatibility. This factor could result in a giant step toward market acceptance.

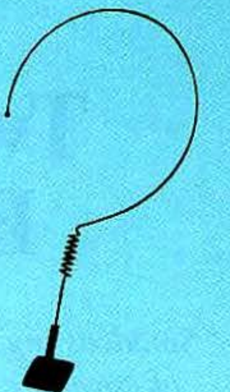
IVHS system promoters need to identify the spectrum where their systems will operate and to create the strategic alliances that will bring the systems to market.

Tomorrow

We are too far along in IVHS development to say the industry is in its infancy, although the child has not yet learned to walk. Many technical and regulatory issues need to be resolved before each system springs to life and matures in the marketplace. As each provider overcomes individual battles, systems will be constructed one by one, and services will develop. Automobiles will become more "intelligent," and IVHS system operators will reap financial benefits from serving millions of motorists. Eventually, car manufacturers will be forced to install IVHS equipment at the factory to keep up with competitive pressures.

IVHS has much to offer the public in convenience, safety and improved traffic conditions. These benefits will be realized long before the "auto-auto" is developed, if ever, for public use. The advances already coming forth will make highways safer and more efficient. The emerging IVHS industry will be entitled to a collective thanks from a grateful public, even if drivers still have to steer their cars.

Getting Maximum Performance from Every Installation



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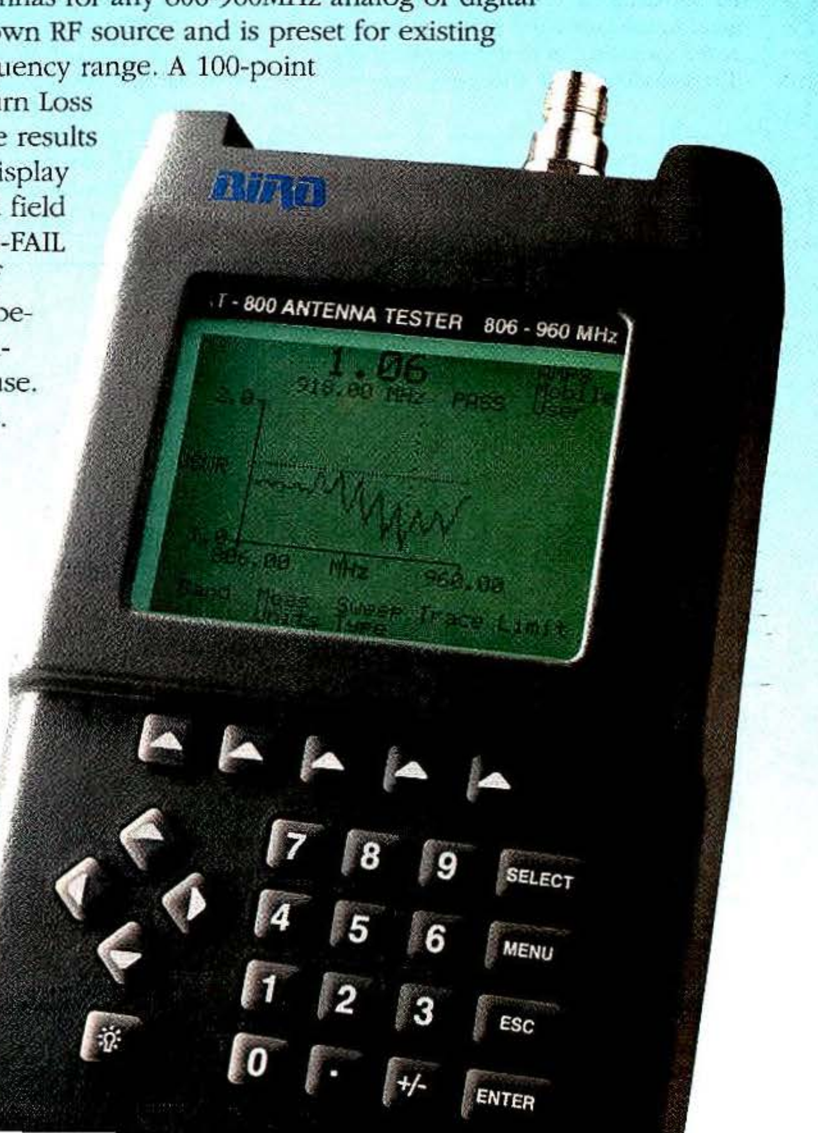

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Two-way simulcasting: Basic considerations

Simulcasting on two-way radio communications systems can solve a variety of coverage problems. Here are some aspects of system design, operation and testing that help to ensure optimum results.

By Jeff Ashley

For many two-way radio communications purposes, a single hilltop repeater may give adequate service area coverage.

When larger areas need to be covered or when coverage gaps must be filled, a simulcast radio system may be the solution.

Simulcast typically refers to a system with more than one transmitter operating on the same RF channel in a particular area, broadcasting the same information at the same time from different locations. The transmitters are effectively *synchronized* with each other.

Ashley is a communications technician with the Los Angeles County Internal Services Department.

A basic list of considerations regarding simulcast systems might include:

1. RF coverage areas, including number of transmitters, transmitter locations, antenna patterns and effective radiated power (ERP).
2. Maintaining transmitter frequency stability.
3. Transmit audio phasing that minimizes phase distortion.
4. Transmit audio deviation levels that minimize amplitude distortion.
5. System testing and aligning.

One of the first considerations is to define the service area so that transmitters may be located appropriately.

While ensuring coverage requirements are met, keep the number of transmitters to a minimum. This not only reduces costs, it also improves system alignment and usually results in a better-sounding system. Bigger is not always better.

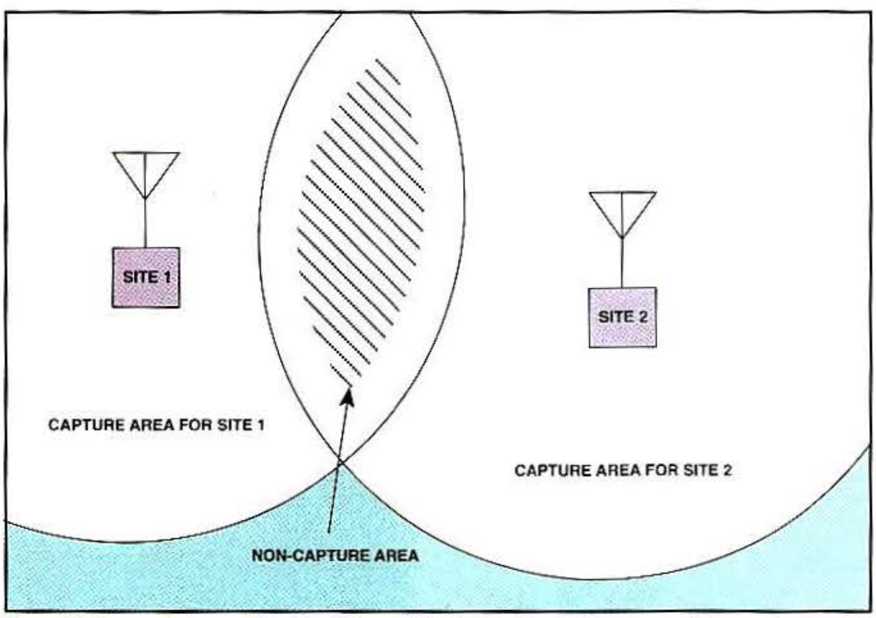

Figure 1. Areas where one simulcast transmitter has a signal strong enough to capture an FM receiver, preventing interference, are called capture areas. In non-capture areas where two or more signals interfere with one another, negative effects may include beat notes (heterodynes), phase distortion and amplitude distortion.

Coverage conditions

Several signal coverage conditions exist in a simulcast system. There are areas where one simulcast transmitter has a significantly stronger RF signal level than another. (See Figure 1 below.)

In these locations, the mobile unit's receiver is *captured*, and the listener does not hear any negative simulcast effects. Such effects include *beat notes* or *heterodynes* when two signals with relatively equal strength add and subtract from one another at a rate equal to their frequency difference. Slow beat notes may be noticed as fading. Faster beat notes produce an audible tone.

(When one signal is sufficiently stronger than another, the FM receiver responds only to the stronger signal and is said to be captured. The phenomenon is known as the *capture effect*.)

Other distortion causes

Phase distortion and amplitude distortion, two other negative simulcast effects, distort the sound of radio communication.

All of the negative simulcast effects may slow or prevent data communications, depending on circumstances.

When the receiver is in a transmitter's *capture area*, reception is good whether or not the simulcast system is properly aligned because a signal from only one transmitter is being received.

Where signals from two or more transmitters overlap at a difference in strength of less than 20dB, negative effects of the simulcast system may start becoming noticeable. Such an area may be called a *non-capture area* or *overlap area*. When the system is properly aligned, these negative effects are minimized.

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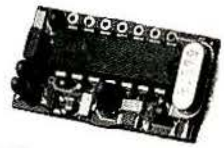

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phased non-capture areas that sound bad even when the system is in alignment. This distortion can result from multipath propagation of transmitter signals caused by reflections and diffractions from large structures such as buildings and terrain features such as hills and canyons.

Multipath propagation can allow a signal from a single transmitter to arrive at a receiver via different routes with slightly different lengths, causing phase distortion that must be tolerated. One can only hope that some or all of the areas subject to multipath distortion will be outside of the target coverage area.

Multipath propagation can allow a signal from a single transmitter to arrive at a receiver via different routes with slightly different lengths, causing phase distortion that must be tolerated.

There may be areas outside of the intended service area where signals from more than one transmitter are received at about the same RF signal level. This kind of reception might be typical of a simulcast system with many transmitter sites that create considerable RF coverage overlap.

Such a system design creates non-capture areas where audio phase distortion results because the system's audio phase has been adjusted for a *different target area*. This negative aspect also must be tolerated.

Each site's location, antenna pattern and ERP are major considerations because they determine where the capture and non-capture areas are. When the ERP at the various sites is adjusted so that the user's primary service area is within a capture area, the user does not have to contend with the effects of beat notes and audio phase and amplitude distortion.

Frequency stability

Another basic consideration is the frequency stability of each simulcast transmitter. Output frequencies of simulcast transmitters on the same RF channel must

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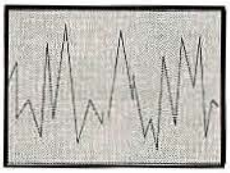

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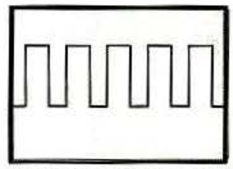

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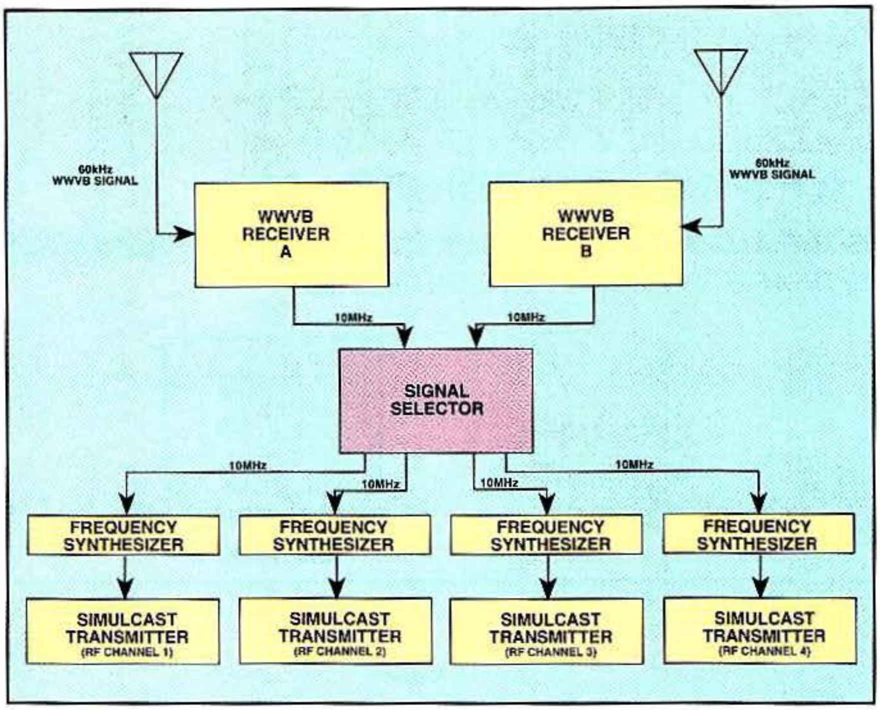


Figure 2. One way to achieve frequency stability is to use a WWVB receiver and associated frequency synthesizers at each transmitter to phase-lock the transmitter frequencies to a standard frequency.

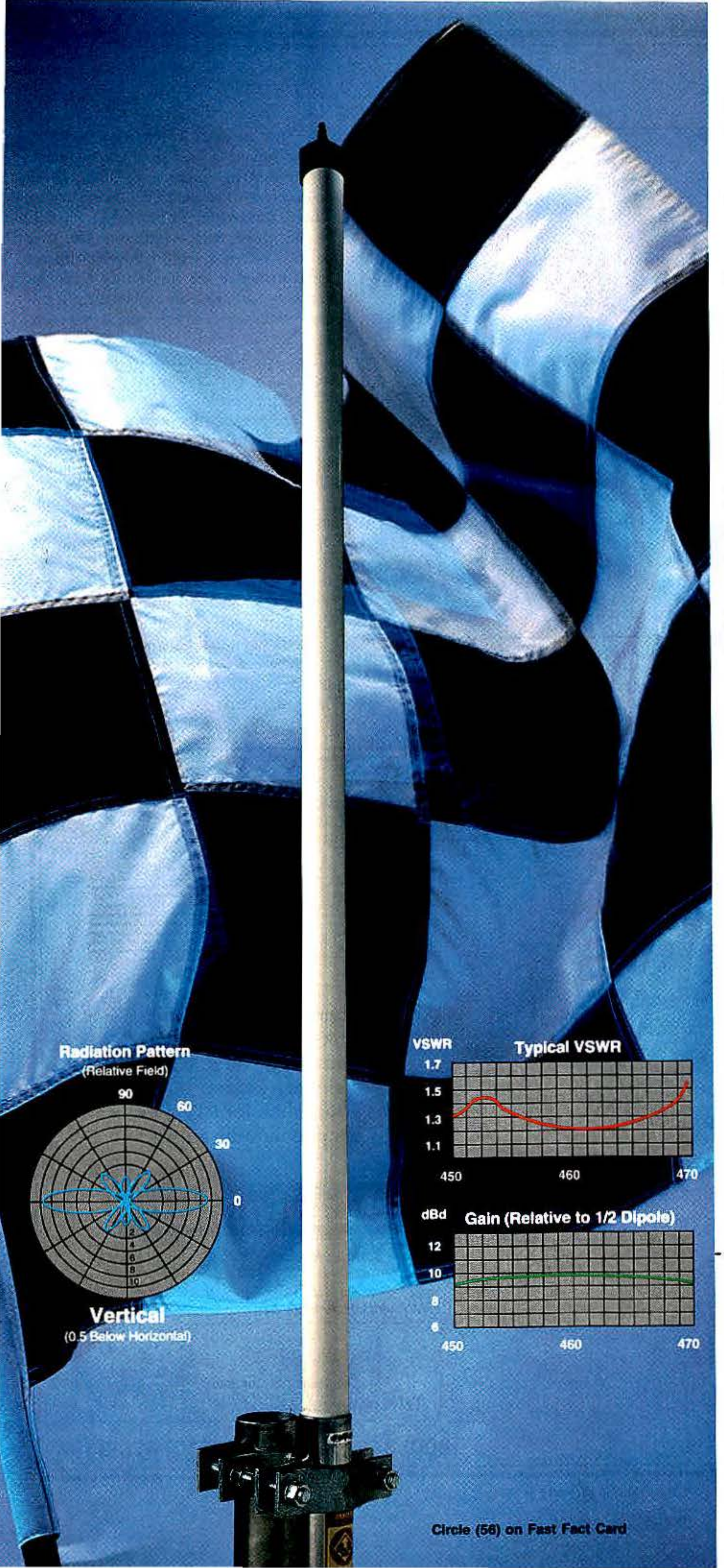
be identical or else a heterodyne will be heard in non-capture areas. There are several ways to make sure the frequencies are identical.

A *high stability oscillator* (HSO) can be used in place of the standard transmitter oscillator circuitry. An HSO allows each transmitter's frequency to be set to within a hertz. Even so, HSOs eventually drift off frequency causing a beat note to be heard in non-capture areas.

For this reason, systems with HSOs require considerable maintenance because technicians must visit each site every few weeks to set the HSOs on frequency. Although the initial equipment costs of this type of system may be lower, long-term costs may be considered excessive because of continual labor required for maintenance.

WWVB

Another way to achieve frequency stability is to use a WWVB receiver and associated frequency synthesizers. (See Figure 2 to the left.) The receiver picks up the 60kHz standard frequency signal broadcast by the National Institute of Standards and Technology station WWVB at Ft. Collins,



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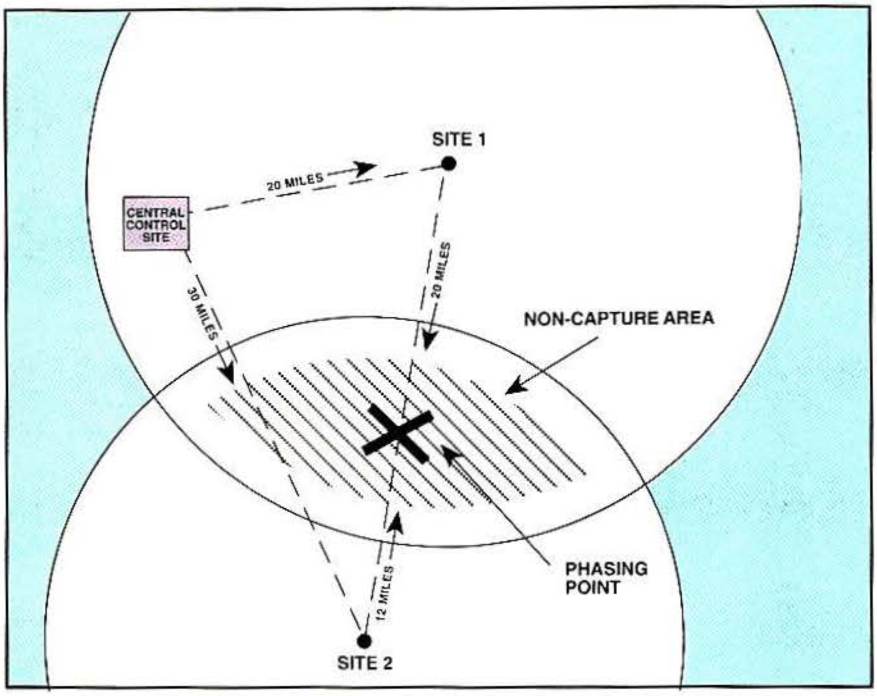

Figure 3. Simulcast sites can be linked to a central controlling site. If the simulcast sites were equidistant from both the central controlling site and the non-capture area phasing point, their respective transmit audio would reach the phasing point at the same time, in phase, and transmit audio phasing would not be a consideration.

CO. This extremely accurate low-frequency source is used to adjust automatically a 10MHz oscillator contained within the receiver to phase-locked accuracy.

Each transmitter in the simulcast system has a frequency synthesizer that uses the WWVB receiver's 10MHz oscillator signal to derive the transmitter oscillator frequency. Because the transmitter oscillator frequency is phase-locked to a standard, no fine-tuning is necessary.

The WWVB receiver usually is connected to a loop or whip antenna with an internal pre-amplifier. The pre-amps typically are powered by a dc voltage source in the WWVB receiver that places a voltage on the center conductor of the coax leading to the loop or whip antenna.

In the event of antenna failure or propagation disturbances affecting WWVB reception, the receiver's 10MHz internal oscillator continues to deliver a fairly accurate output signal to the synthesizers. The phase-locked condition returns when WWVB reception is restored.

Another option for frequency stability is to purchase a *frequency standard* to be placed locally at each transmitter site. These standards typically are rubidium-

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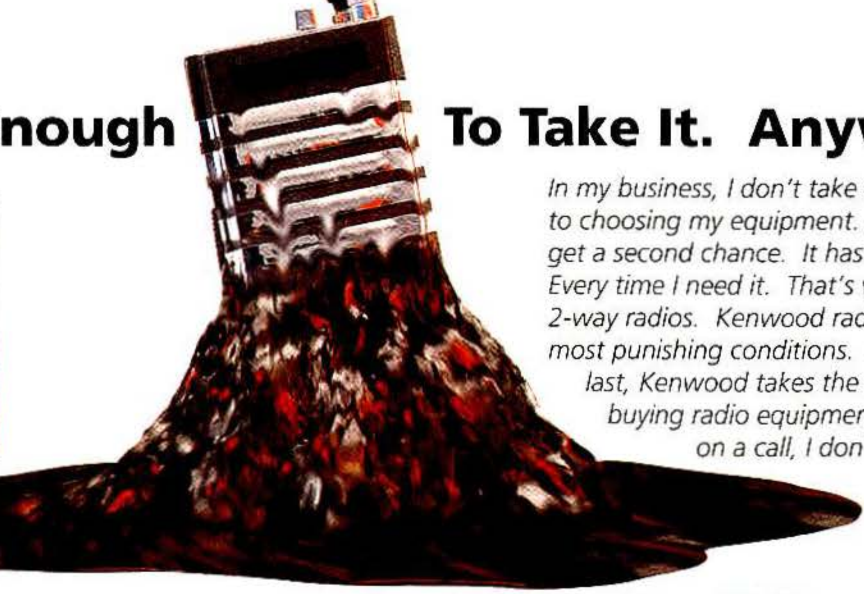

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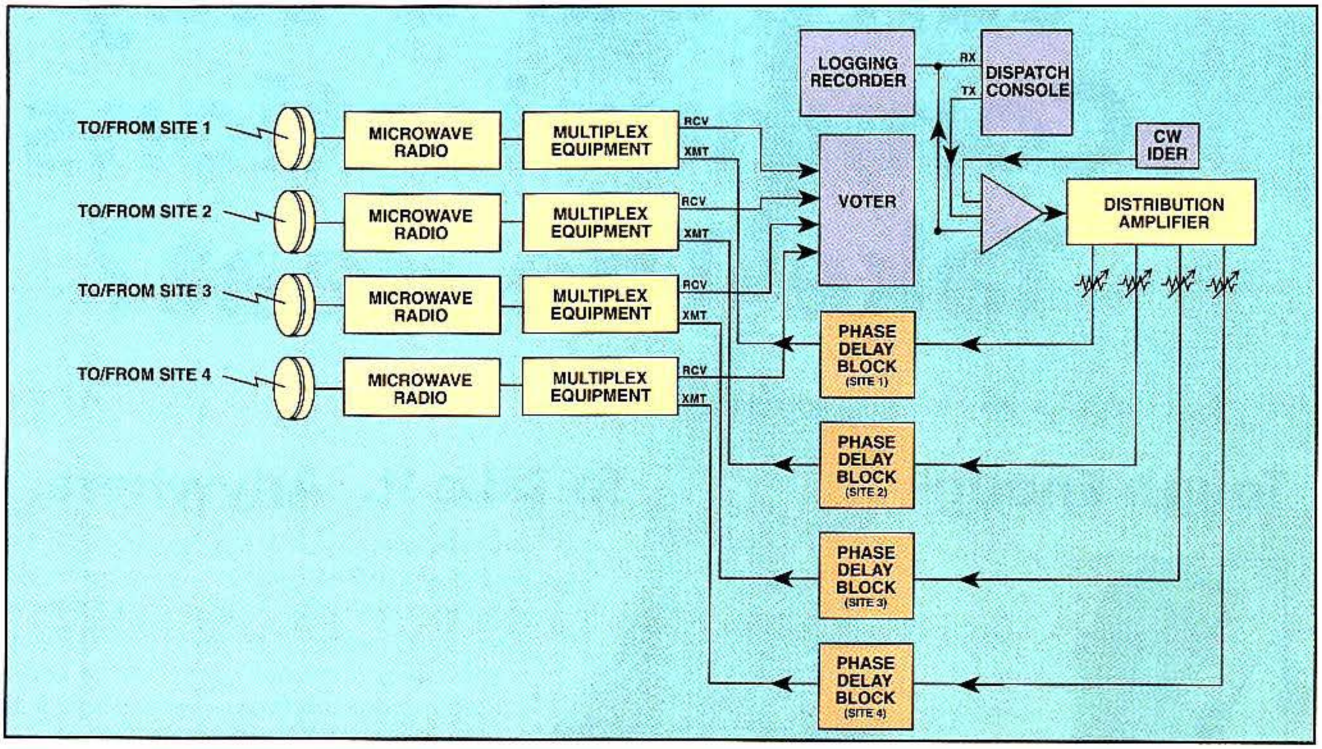

Figure 4. At the central controlling site, incoming audio from each remote site is sent to a voter where the best quality signal is chosen. The voted audio then is sent to a distribution amplifier that provides isolated outputs for each site's delay blocks.

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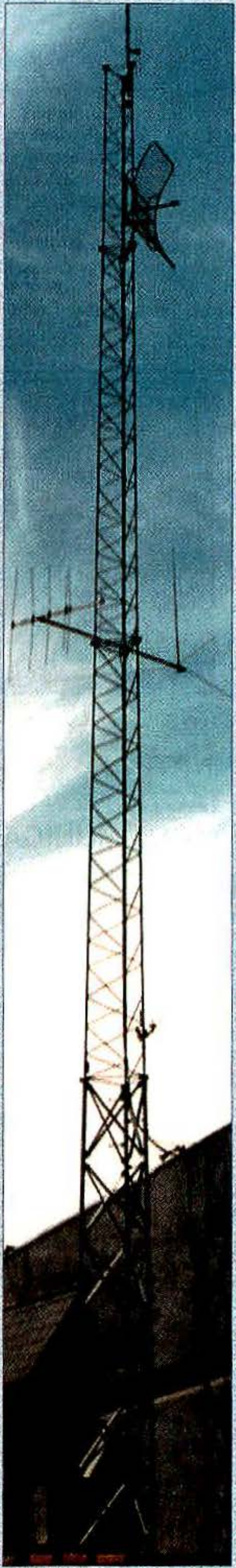

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based and sometimes have an accurate quartz-based oscillator as a back-up. As in the 60kHz system, the standard produces a 10MHz output signal that is fed to a frequency synthesizer. Because the frequency standard works independently at the transmitter location, WWVB reception is not necessary.

Audio phasing

The next consideration in a simulcast system is *audio phasing* among two or more transmitters.

In capture areas, audio phasing is not important because only one transmitter's audio is heard, thanks to the FM receiver capture effect.

In non-capture areas where transmit audio from different transmitter sites is not in phase (i.e., does not arrive at the user's receiver at the same time), distortion results. This distortion makes the received audio sound noisy and garbled. The user may say the audio sounds as though it is "tearing up."

Audio phase cancellation may occur, making the simulcast transmissions sound as though they have low frequency deviation.

The objective in adjusting the audio phasing among the transmitter sites is that the entire audio spectrum that they broadcast should exhibit the same phase and amplitude characteristics in a designated non-capture area.

Central controlling site

Figure 3 on page 64 shows how simulcast sites can be linked to a central controlling site. If the simulcast sites were equidistant from both the central controlling site and the non-capture area phasing point, their respective transmit audio would reach the phasing point at the same time, in phase, and transmit audio phasing would not be a consideration. This condition, though, rarely can be achieved.

When mobile units in the field transmit, their signals may be received by one or all of the simulcast site radio receivers. This received audio is sent to a central controlling site via microwave.

At the central controlling site, incoming audio from each remote site is sent to a voter where the best quality signal is chosen. (See Figure 4 on page 66.) The voted audio then is sent to a distribution amplifier that provides isolated outputs for each site's delay blocks.

The delay blocks insert a specific delay in each site's transmit audio line to compensate for differences in propagation delay caused by the different distances between the central controlling site and the simulcast transmitter sites, as well as differences in distances between the simulcast transmitter sites and the non-capture area phasing point.

Avoid telephone lines

Because these distances and the resultant propagation delays are critical to the system design, linking the central controlling site with telephone lines could be a nightmare. The circuit could be routed through any number of central offices on its way to the remote simulcast sites. The route and method of transmission would be unknown, resulting in a propagation delay that would be impossible to calculate.

In Figure 3, the distances (in air miles) from the central controlling site to the non-capture area phasing point (via the simulcast transmitter sites) are shown. From these distances, actual time delays for each path can be calculated. (The delays are

about 5.6 microseconds per mile, or 2° per mile with a 1,000Hz tone.)

All propagation delays through multiplex (MUX) modems, microwave radios and simulcast transmitters must be included in the calculations. The site with the shorter distance will have more delay inserted into its respective delay block so that its signal reaches the phasing point at the same time and with the same phase as the site having the greater distance.

The maximum phase difference between transmitters might be specified at around 30° in the 400Hz–2,800Hz range, with actual operating conditions at about 1/3 of that figure.

Audio deviation

Discrepancies in simulcast transmitter audio deviation levels are another factor that can account for system performance degradation.

Not only should transmit audio levels through the equipment at the central controlling site be checked at regular intervals, but also the MUX and radio equipment at the remote sites. System design tolerances for amplitude variations between transmitters might be in the order of 0.75dB at 400Hz–2,800Hz, whereas with a regular alignment schedule, actual values can be 1/3 of that figure.

If a sub-audible tone is used on the simulcast transmitter's carrier, it too must be phased properly, and its transmit deviation level must be maintained closely. When possible, it may be advantageous to avoid using a sub-audible tone to reduce equipment and alignment costs.

Test and alignment

Because transmit audio levels and phases have to be watched and maintained so closely, a test and alignment set-up should be an integral part of the simulcast system.

The test and alignment setup typically is located at the central controlling site. It should be equipped with a transmitter control panel where each site's transmitters can be individually keyed or disabled.

In addition, satellite test receivers are located at remote sites within the desired coverage area and are used to monitor the output frequency of the various simulcast transmitters. The remote test receiver's recovered audio can be sent back to the central controlling site test and alignment equipment by microwave. This setup allows a technician in the central controlling site to monitor the system's performance.

Transmitter output frequency, audio deviation and phase differences among simulcast transmitters may be measured and compared with these test receivers.

Audio sweep generator

The audio phase comparisons are accomplished in the central controlling site by switching an audio sweep generator to the distribution amplifier input in place of the voter output. (See Figure 5 below.)

This configuration allows the practical audio passband of each simulcast transmitter (about 400Hz to 3,000Hz) to be swept while the transmitter is keyed

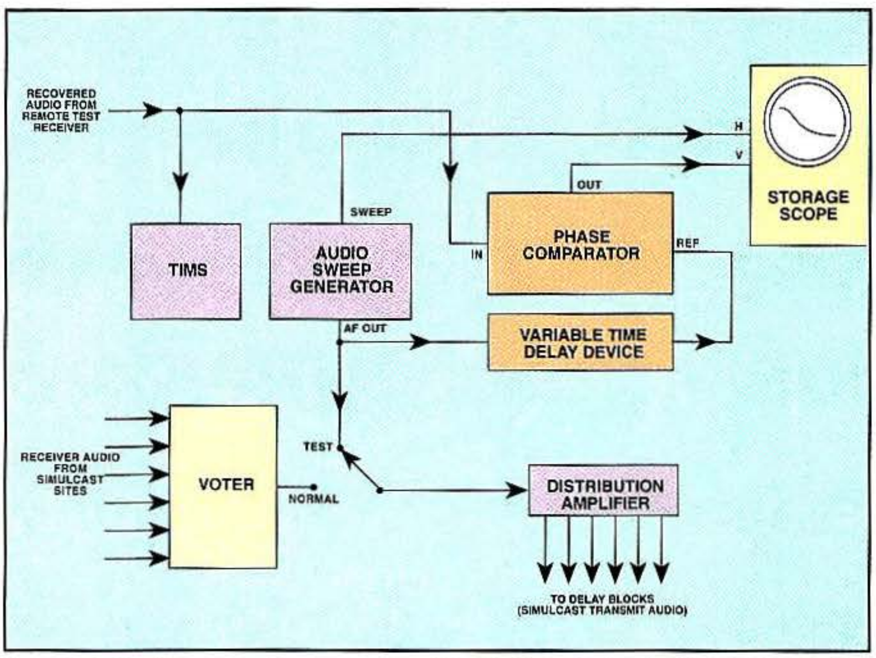

Figure 5. Audio phase comparisons are accomplished in the central controlling site by switching an audio sweep generator to the distribution amplifier input in place of the voter output.

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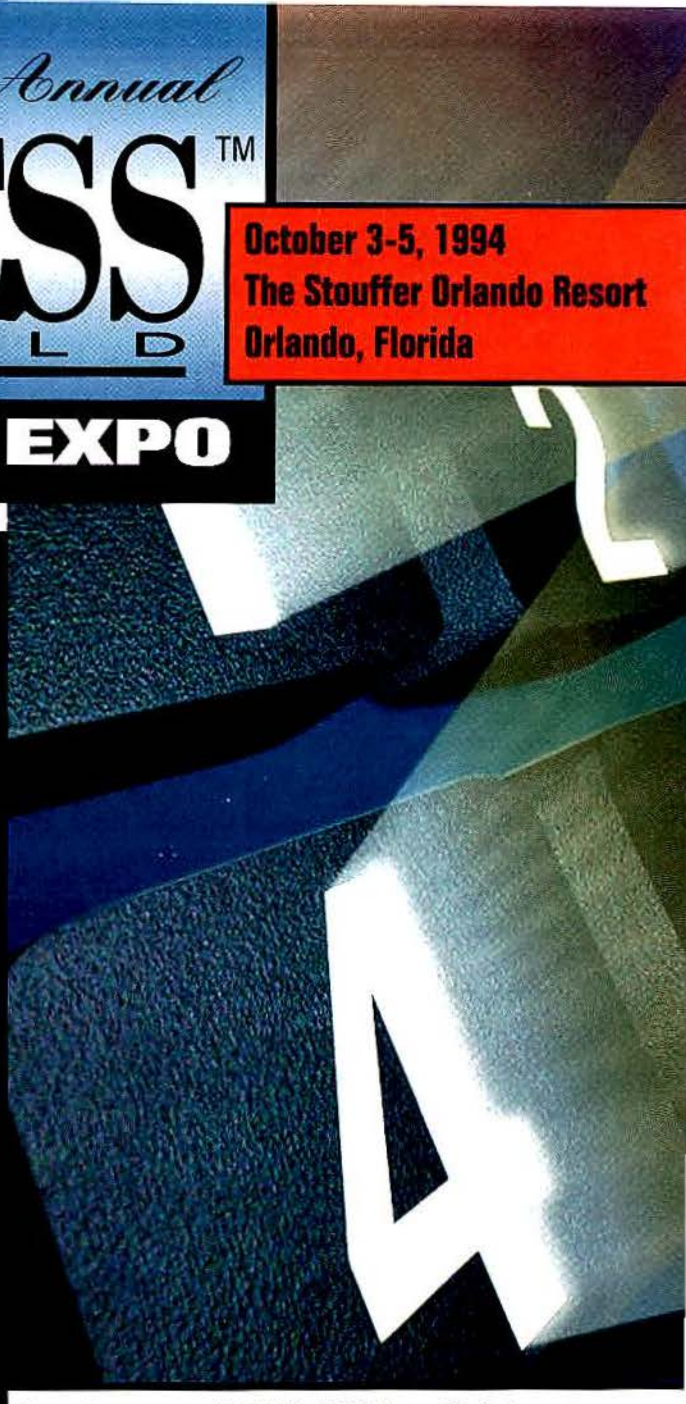

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individually via the transmitter control panel. The keyed transmitter's output signal then is received by a test receiver.

Recovered audio is sent back to the central controlling site via microwave where it drives one input of a phase comparator. The other phase comparator input is connected to the local audio sweep generator. The phase comparator output voltage represents the phase difference between the original audio source (local audio sweep generator) and the recovered audio after transmission.

This phase voltage drives the vertical axis of a storage scope. The horizontal axis is driven by a ramp voltage from the local audio sweep generator and represents the audio frequency range being swept. The trace these voltages produce could resemble the storage scope display in Figure 5.

After choosing one site as the permanent reference, that site's transmitter is keyed and swept, creating a reference trace on the storage scope. The transmitter is unkeyed, and the next simulcast site transmitter is keyed and swept, superimposing another storage scope trace on the first.

This procedure is repeated for all the transmitters on the RF channel while time delays are added or subtracted from the various delay blocks until all traces on the storage scope display look almost the same as the reference transmitter's trace.

If the test receiver is located at the non-capture area phasing point, audio phase alignment is complete. Unfortunately, it is rare that the receiver can be located so strategically; more often, it is located at one of the simulcast sites.

If so, even when the system is in perfect audio phase alignment with respect to the desired phasing point, the storage scope in the test and alignment setup will show traces that indicate incorrect phasing because the distance between the simulcast sites and the test receiver is different from the distance between the simulcast sites and the phasing point. The difference in distances must be compensated for by inserting a variable time delay device in the test and alignment setup so delays can be switched in and out for different sites during the alignment procedure. (See Figure 5.)

Transmit audio levels

Another use for the test receiver is to monitor the transmit audio levels from each site's transmitters.

The audio sweep generator in the central controlling site may be used to generate a single 1kHz tone to modulate each site's transmitters one at a time. The test receiver's recovered audio level then can be measured in the central controlling site with a TIMS or other level-measuring device to determine whether the transmit audio levels among sites are within the prescribed tolerances.

Often, on large simulcast systems, a dedicated microcomputer is connected with the test equipment to measure and compare transmit audio levels and other system characteristics. Test results can be displayed in *pass/fail* form or as absolute values.

Simulcast systems require special design, equipment and care with regard to testing and alignment. Despite their complexity, the systems may be just what is necessary to cover large areas or to fill in coverage gaps that conventional single mountain-top repeaters cannot.

What technicians should know about fiber-optic installation

Part I—As technicians' responsibilities increase beyond radio systems, skills with fiber-optics help them to service a broader range of communications installations. Here is some help for getting started.

Wayne R. Gipson, C.E.T.

One of the greatest challenges in data communications is the quest for information transfer that is at once fast, efficient, cost-effective, reliable and, most of all, accurate.

Network designers in increasing numbers are abandoning copper and radio frequency media in favor of glass fibers smaller than a human hair. The following information explains the fiber's advantages, how it is made, characteristics that affect its performance and how it is installed and connected.

The fiber-optic concept is simple. A light source either emits fast light pulses (digital) or varies the light's intensity (analog) through a clear *coax* of glass or plastic to a receiver where the changes are interpreted and used to re-create a signal.

This coax can be fashioned and refined in a number of ways that allow it to pass the light signal with minimum loss or alteration.

Gipson is a senior communications technician with experience in fiber-optic specification, installation, splicing and connectorization. He has an FCC General Radiotelephone Operator license and an ISCET-certified electronics technician certificate. He lives in Wichita, KS, where he works for Western Resources, a utility company.

Siecor, Hickory, NC, provided the photographs used in this article.

Noise immunity

Why does the use of optical fiber offer an advantage? Consider the limitations of alternate means.

Copper conductors are susceptible to nearby electrical noise and interference, as in a factory with many electrical devices such as motors, electrical switchgear, arc welders and lights.

Electrical noise induced into a copper cable pair disrupts data carried on the line. Voltage noise spikes corrupt, mask or alter the data because the receiving device cannot tell a noise spike from a data pulse. Light is unaffected by electromagnetic noise, so fiber can carry data reliably through noisy areas.

In the utility industry, electrical substations control potentials of 345,000V or more. Substations monitor and direct the electricity along desired paths; monitor lines for faults (paths to ground); and insert capacitors across the lines (to counteract inductive reactance on long transmission lines).

Transformers reduce potentials entering the substation to levels useful to customers, and sophisticated equipment accurately meters the delivery of the electricity. Optical fiber can be used to send and receive data from the substations to a control facility where the data is analyzed and acted upon. These fibers are installed on the transmission line structures either as separate, stand-alone cables under the power lines or manufactured in the *static* or *ground wire* spanning the structures over the energized lines.

Because the great amount of electrical energy in its vicinity does not affect the fiber's performance, data passing along the fiber through the substation is uncorrupted.

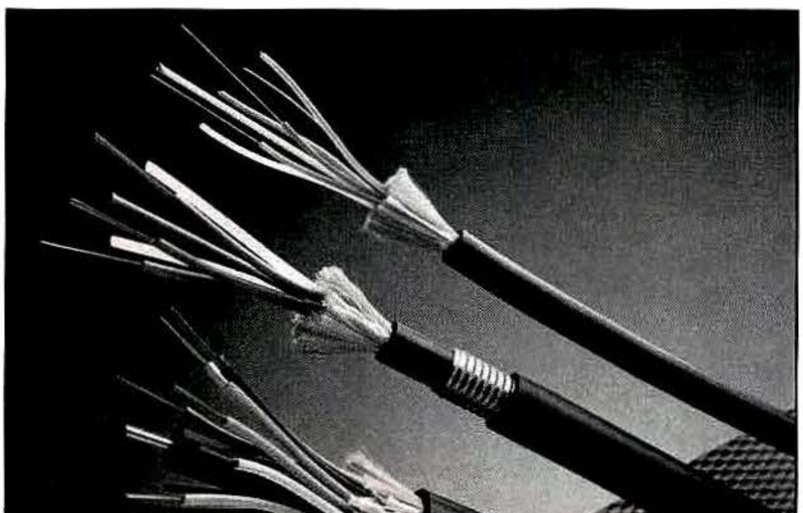

Photo 1. These are examples of loose-buffered, outside plant cables. The top cable has a dielectric central member and loose tubes with low fiber counts that wrap around the central member. The middle cable is a rodent-proof, armored underground fiber. The bottom cable is a high fiber count outside cable with a metal central member.

Electrical isolation

The fiber, made of glass, does not conduct electricity; therefore, communications equipment such as the telephones that maintenance crews use to talk to the control center can be isolated from potentially

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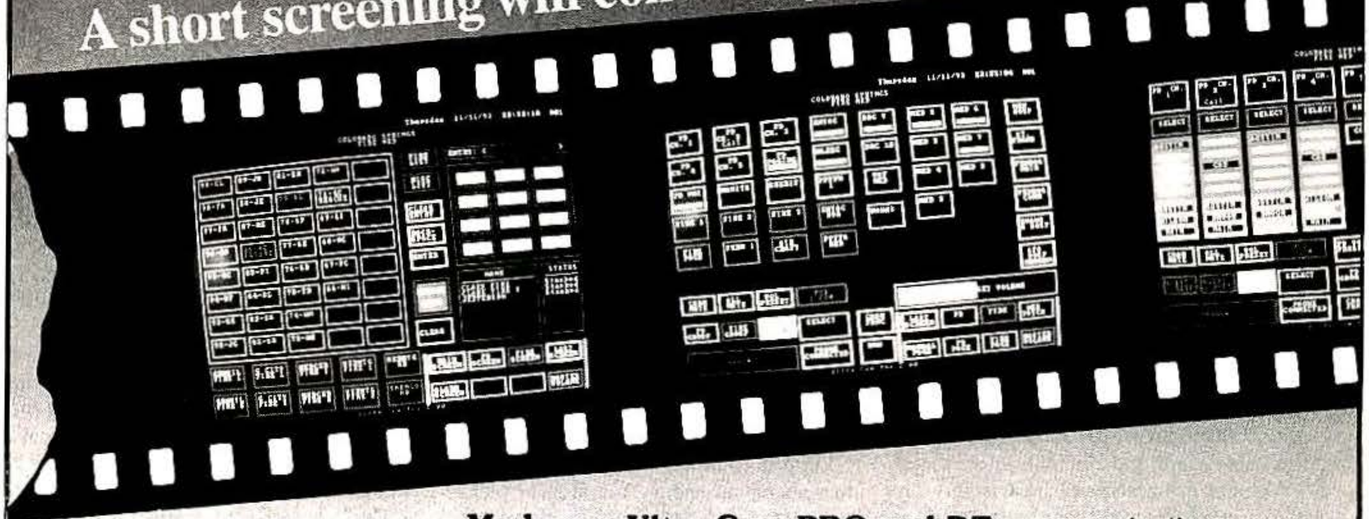

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station.

Fiber is routed from inside the substation to a box outside of the perimeter fence. The telephone company lines connect to an interface box that converts the signaling and voice (or data) to light to be sent through the fiber to a similar interface inside the substation. This configuration isolates the telephone company equipment from the substation equipment.

Two-way radio units mounted in vehicles generally have a control head mounted on or near the dashboard within easy reach of the driver. The radio transceiver usually is mounted in the trunk. The two normally are connected by a thick control cable. Because of its bulk, the cable is often difficult to hide under the carpet.

In addition, it can act as an interference conductor. The cable can carry unwanted radio energy that might interfere with a vehicle's cellular telephone, stereo and controls. Similarly, interference from vehicular devices may be induced into the radio, impairing its performance. Substituting a small optical fiber can greatly reduce the control link cable's bulk and eliminate interference.

Vehicle manufacturers increasingly are using optical fiber made of plastic to replace vehicular control cables. Such cables eliminate the danger of electric sparks, making them an attractive choice for use near fuel lines and storage tanks.

Because optical fiber cannot carry electric current, it is ideal for carrying data in areas likely to be struck by lightning.

Because communications by light carried on optical fiber are not regulated as most radio and microwave communications are, no license is required.

Secure communications

Light is confined inside the fiber, and it does not radiate energy that might be picked up and decoded. This attribute makes optical fiber a communications medium that is secure from eavesdropping.

If the fiber *were* bent or spliced to allow some light to escape for monitoring, the bend would be detected easily by the network monitor because the light intensity would diminish. In high-security applications, optical fiber is an ideal communications medium.

No licensing

Because communications by light carried on optical fiber are not regulated as most radio and microwave communications are, no license is required. As closed-circuit media, fiber-optic communications share no frequencies with other users.

With increasing demands on a finite spectrum, radio reception is becoming noisy due to the sheer volume of traffic. Adjacent channel traffic, even when operating according to regulations, creates noise that can corrupt data.

Free from licensing and regulation, a fiber-optic data link can be put in place and used immediately without the governmental permission normally required for radio use. Such permission, when it can be obtained, sometimes involves delay.

Optical fiber is the answer to many data communications needs; nevertheless, fiber

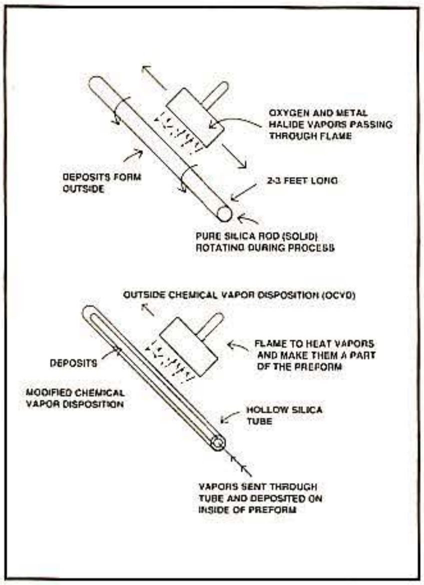

Figure 1. In the United States, manufacturers use two processes to make the glass *preform*. AT&T uses the *modified chemical vapor disposition process* in which soot that changes fiber light path characteristics is deposited inside a pure glass tube. Corning Glass Works uses the *outside chemical vapor disposition process* in which the soot is deposited on the outside of the preform. The preforms are the raw material from which fiber is drawn.

data systems require special installation knowledge and skills for reliable results.

Light conductor

Optical fiber is a *light conductor* with conductive and reflective characteristics that vary within the fiber cross-section. The center of the fiber cross-section—the *core area*—conducts light, whereas the outer area—the *cladding*, is altered by chemical deposits during manufacture so that light straying from the core area reflects back to the core and along the length of the fiber to its destination.

The core and cladding are inseparable parts of the same piece of glass. (Plastic fiber generally is not used for data transmission. The following information applies to glass fiber.)

Manufacturing process

There are several ways of manufacturing fiber, and they all involve taking a *preform* of glass and subjecting it to chemical vapors. (See Figure 1 to the left.)

After the chemicals and glass are melded together, the preform is subjected to dehydration to eradicate water that, when present in the fiber, creates unwanted attenuation.

The preform then is placed in a tall drawing tower that precisely pulls a tiny glass fiber from the preform. (See Figure 2 on page 78.) A preform produces as much as 100km of fiber.

After being drawn, the fiber is coated immediately with a pliable, strippable plastic material for protection and to keep it from absorbing water. This coating can be colored to identify the fiber when it is is bundled with others in a cable. Figure 3 on page 78 shows a cross-section of fiber and typical diameters. Fibers are precision-made to various specifications.

Optical fiber is a light conductor *with conductive and reflective characteristics that vary within the fiber cross-section.*

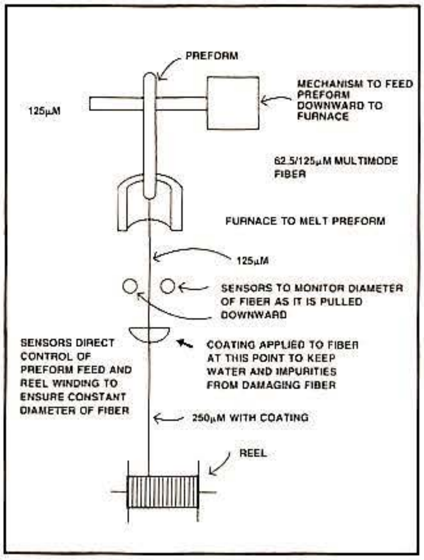

Figure 2. The preform is placed in a tall drawing tower that precisely pulls a tiny glass fiber from the preform. A preform produces as much as 100km of fiber.

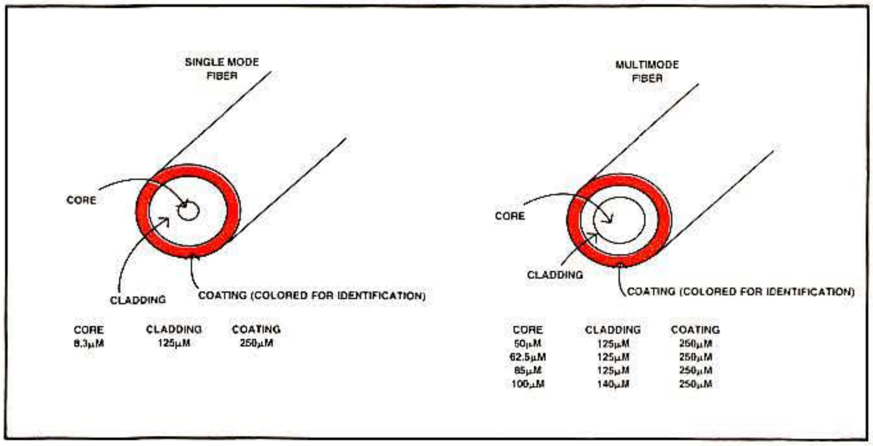

Figure 3. These cross sections show fiber construction and typical diameters. Fibers are precision-made to various specifications.

Fiber types

There are two types of fiber, *single mode* and *multimode*. In fiber-optic terminology, *mode* refers to the number of paths the light may travel.

Both fiber types rely on *total internal reflection*. (See Figure 4 on page 80.) If light enters a fiber inside its *acceptance angle*, the light travels along the fiber and reflects from the cladding until it reaches the other end.

Multimode fibers have a core size from 50 micrometers to 100 micrometers in diameter. The most popular size is 62.5 micrometers.

Single-mode fibers have core diameters of only 8 micrometers or so.

Cladding for both fiber types is 125 micrometers to 140 micrometers thick.

A larger core diameter provides more lightwave paths; that is, it passes more wavelengths of light, and the single-mode fiber passes only a restricted light wavelength.

Multimode fiber is used with light-emitting diode (LED) transmitters that are inexpensive, but the fiber must have a larger

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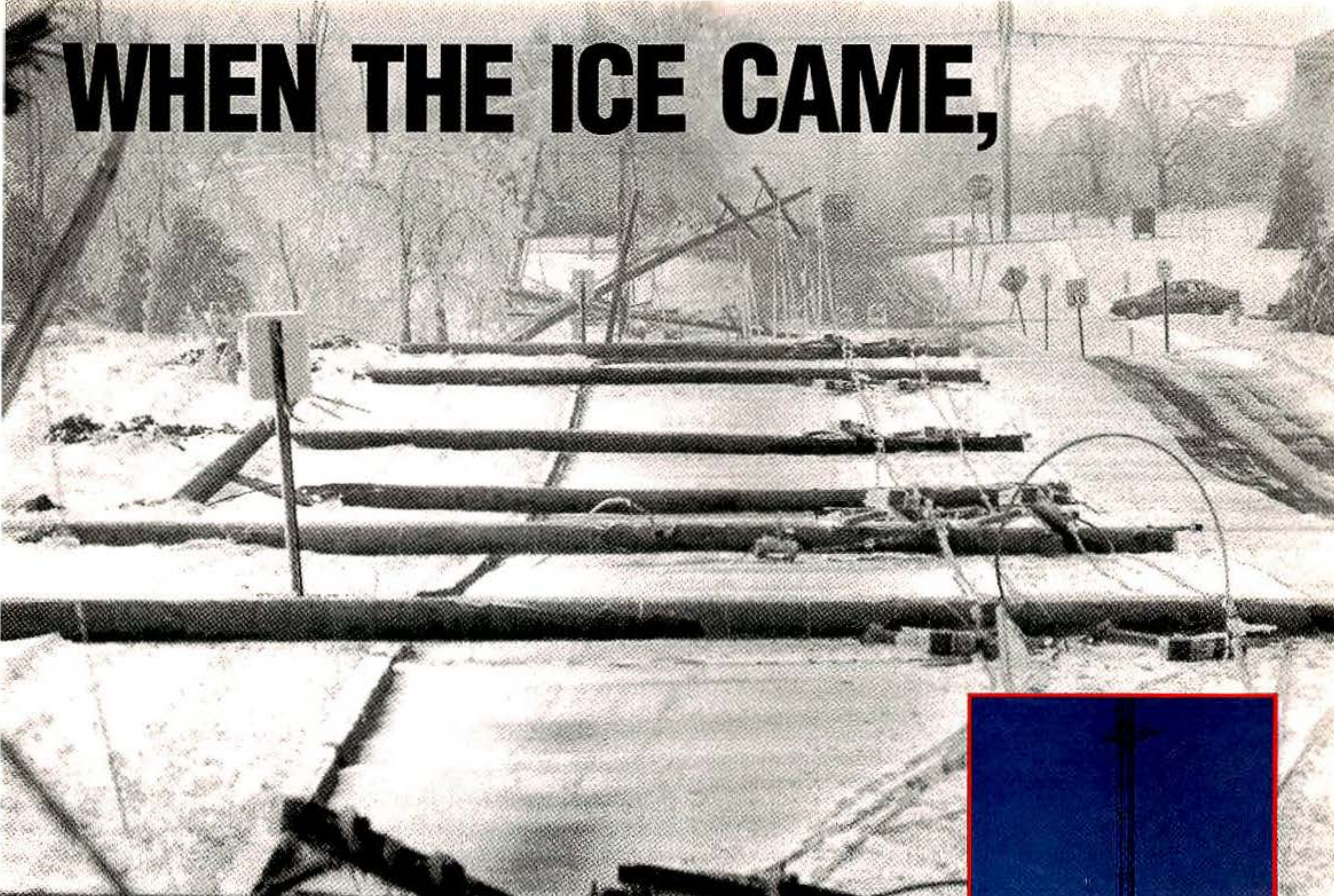

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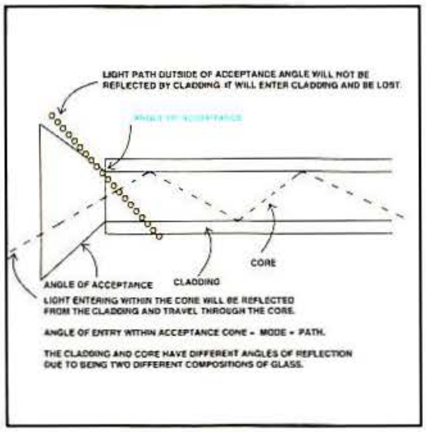

Figure 4. A side view of a fiber cutaway illustrates the concept of total internal reflection.

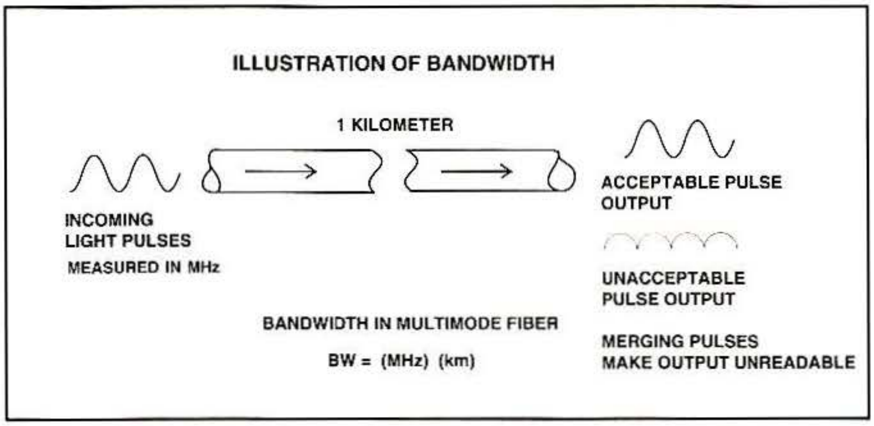

Figure 5. As in any communications medium, a signal (light pulses) sent through fiber experiences some quality degradation. A certain amount of definition loss is acceptable, but at some point the pulses cannot be read properly at the receiver. *Bandwidth* is the highest number of pulses that can be sent per second without reception errors at the end of a fiber 1km long. Bandwidth is a factor in multimode fiber because the diverse paths taken by the light causes interference. In single-mode fiber with only one path, bandwidth is not a factor.

acceptance cone because of the relatively incoherent light energy paths the LEDs generate, compared to lasers. These multiple paths eventually limit the fiber's bandwidth because the varying paths eventually degrade the light pulses so much that errors result. (See Figure 5 above right.) Bandwidth varies inversely to the fiber length.

Laser light

Single-mode fibers have a much smaller angle of acceptance and use lasers for transmitters. Laser light is coherent, meaning that, theoretically, the energy travels in one wavelength. A lack of divergent wavelengths means that the signal can be sent without light pulse degradation.

The limiting factor on single-mode fiber, which is caused in manufacturing, is *dispersion*. Over a long distance, the slight difference in how the cladding and core reflect light eventually creates interference with the light pulses' definition.

Multimode transmission generally is limited to a range of 2km, although some fiber-optic transmitter and receiver manufactur-

ers claim that their products extend this range to 5km. Single-mode fiber easily can transmit a pulse 50km or so before *regeneration*—the rebuilding of the light pulse—is necessary.

Light wavelengths used in multimode fiber are 850 nanometers and 1,300 nanometers. In single-mode fiber, light wavelengths of 1,310 nanometers and 1,550 nanometers are used. These wavelengths are not chosen arbitrarily, but because of fiber manufacturing characteristics.

These wavelengths represent natural dips in the attenuation the fiber presents to light traveling through its core because of water molecules in the glass. Better manufacturing techniques have reduced the amount of water in fiber and thus the attenuation the impurity causes.

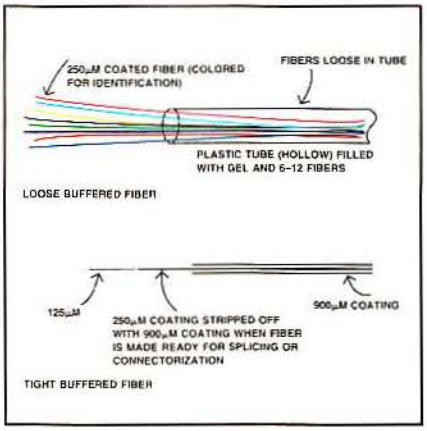

Figure 6. Fiber cables generally are characterized as loose-buffered or tight-buffered.

Fiber in cables

Once the fiber is manufactured, it must be sheathed for protection.

Fiber cables generally are characterized as loose-buffered or tight-buffered. (See Figure 6 to the left and Photo 1 on page 74.) Tight-buffered cable is coated with plastic that increases its diameter to about 900 micrometers. The coating usually is color-coded for easy identification.

Connectors generally can be applied to plastic-coated fiber without further protection, provided that the fiber, once installed, is not disturbed.

Loose-buffered fiber is delivered with coating only 250 micrometers thick, and it, too, generally is color-coded.

Fibers in a cable may be placed in tubes wrapped around a central member that provides some protection against bending the cable in such a small radius that the fibers are damaged. Alternatively, the fibers may be delivered in a hollow, stiff tube.

Ribbon fibers, which are bundled together by polyester tape, deliver a high fiber count with as many as 144 fibers per cable.

Loose-buffered fiber is placed in gel filled tubes.

Next month: Specifying cables, cable losses, splicing, connectors and the power budget.

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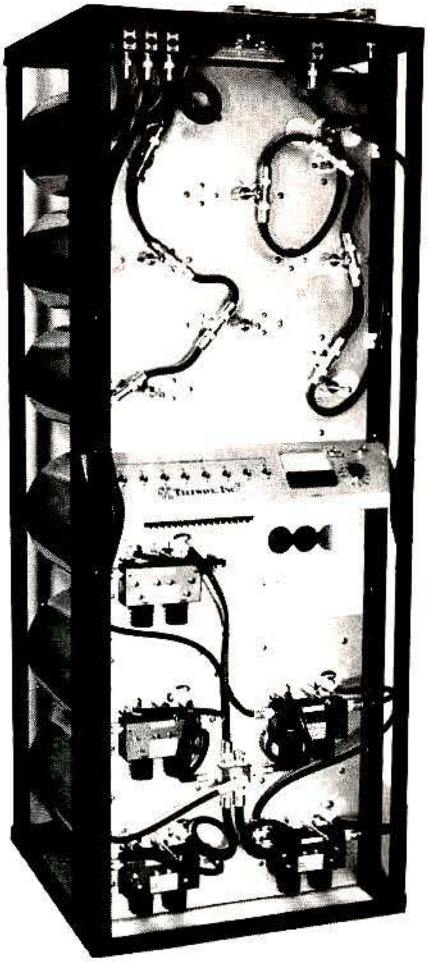

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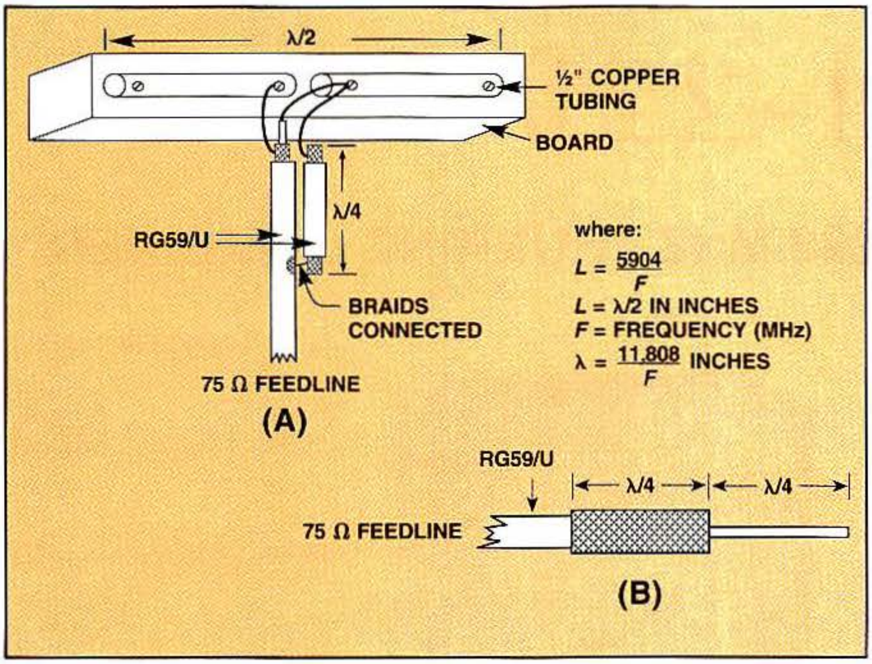


Figure 1. The wideband antenna (A) can be constructed easily with a board and ½" copper pipe. Because the antenna is balanced, a balun is needed to connect it to an unbalanced feedline line. The balun is constructed as shown. This antenna is suitable for highband VHF. The other antenna (B) is much simpler to construct for UHF and 800MHz applications. The braid is simply folded back over the outer jacket to form a halfwave dipole.

(continued from page 8)

Formulas 3 and 4 are used when the antenna is a unity-gain (0dBd) type and the line losses are negligible. These formulas provide a close estimation. These are rather simple and straightforward.

Example for Formula 3: If a unity-gain antenna is placed in a field intensity of 150μV/m at a frequency of 160MHz, what is the signal level in μV at the receiver input, assuming no line loss. Substituting these figures into Formula 3, the keystrokes are:

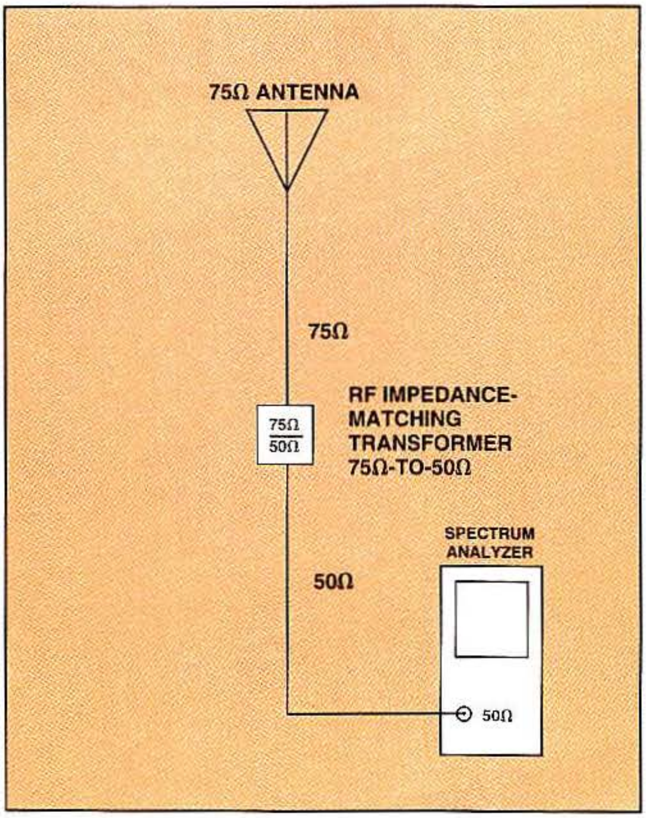
40 (×) 150 (=) (÷) 160 (=) **37.5**, or 37.5μV at the receiver input.

Example for Formula 4: A unity-gain antenna is connected to a receiver operating at 455MHz. If the line loss is negligible, what must the field intensity be to produce a signal level of 1.5μV at the receiver input? Substituting these figures into Formula 4, the keystrokes are:

455 (×) 1.5 (=) (÷) 40 (=) **17.0625**, or 17.11μV/m.

Example for Formula 5: Convert 0.35μV to dBm units. Keystrokes:

Figure 2. A 75Ω antenna system is used with a 50Ω spectrum analyzer input to make field intensity measurements. An RF impedance-matching transformer (75Ω-to-50Ω) is used to match the 75Ω antenna impedance to the 50Ω spectrum analyzer input impedance. The insertion loss of the RF transformer, the antenna factor (K) and the line loss must be taken into account when determining the field intensity from the dBm level on the spectrum analyzer.



(.) 35 (LOG) (×) 20 (=) (−) 107 (=) −116.1186391, or −116.1dBm.

Example for Formula 6: Convert −100dBm to μV units. Keystrokes:

100 (+/−) (+) 107 (=) (÷) 20 (=) (INV) (LOG), which displays 2.238721139, or 2.2μV.

Example for Formula 7: Convert 25μV/m to dBu units. Keystrokes:

25 (LOG) (×) 20 (=) 27.95880017, or 28dBu.

Example for Formula 8: Convert 28dBu to μV/m units. Keystrokes:

28 (÷) 20 (=) (INV) (LOG), which displays 25.11886431, or 25.1μV/m.

An example for Formula 9 was given earlier.

Example for Formula 10: An antenna with a correction factor (K) of +10.5dB/m is placed in a field intensity of 75μV/m. The line loss is 1dB. What is the signal level in dBm at the receiver input? Keystrokes:

75 (LOG) (×) 20 (=) (−) 107 (−) 10.5 (−) 1 (=) −80.99877473, or −81dBm.

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Technically speaking

Example for Formula 11: A 50Ω antenna system has a gain of 3.5dBd at 450MHz. What is the antenna correction factor (K)? Keystrokes:

450 (LOG) (×) 20 (=) (−) 3.5 (−) 32 (=)
17.56425027, or 17.6dB/m.

Example for Formula 12: A 75Ω antenna system has a gain of 3.5dBd at 450MHz. What is the antenna correction factor (K)? Keystrokes:

450 (LOG) (×) 20 (=) (−) 3.5 (−) 33.7
(=) 15.86425027, or 15.9dB/m.

A certain pager specification sheet reads that, for 20dB quieting, a signal level of 0.5μV is required at the antenna jack, or the pager must be placed in a field intensity of 25μV/m for 20dB quieting. Calculate the gain (dBd) of the pager antenna atan operating frequency of 155MHz.

First, using Formula 4, we find that a unity-gain (0dBd) antenna requires a field intensity of 1.9375μV/m for a signal level of 0.5μV at the receiver. The pager antenna requires 25μV/m. Thus, the gain of the pager antenna compared to a unity-gain antenna is: $20\log(1.9375/25) = -22.2$dBd. The pager antenna has a loss of more than 22dB compared to a unity-gain (0dBd) antenna.

There are many other formulas pertaining to signal level vs. field intensity—too numerous to list here. If you would like a list of more than 40 formulas pertaining to this topic along with worked-out examples, send $2 plus $1 for shipping and handling to the author at 204 Tanglewylde Drive, Spartanburg, SC 29301-2949.

A program that instructs an IBM-compatible computer to perform these computations is available on a 5¼" floppy disk. Send $5 plus $1.50 for shipping and handling to the author at the address above. The program is available on a 3½" floppy disk for 50 cents more.

I hope that this has taken some of the mystery out of field intensity units vs. signal level units. Remember that these formulas are based on a 50Ω system impedance. If you use a 75Ω antenna system, be sure to use an impedance-matching transformer or pad between the 50Ω receiver input and the antenna. Also, use Formula 12 to determine the *K* factor (unless it is known). Then use one of the formulas involving the *K* factor (Formulas 9 and 10). By using one or more of these formulas, you can convert from almost any field intensity unit to almost any signal level unit and vice versa. Stay tuned!

Regulating technology

Cashing in on crime

By Robert H. Schwaninger Jr.

On Jan. 25 I sat dutifully before my television set, watching President Clinton's State of the Union address. In Washington, this pastime is endemic among those of us who become political junkies. Given my blue-collar background, I have to admit that the independent channels were showing really bad reruns.

While I listened to the president, I started to list in my mind the services and programs that he would like to deliver to the American public. For example, he said that he supported legislation that would place 100,000 new police officers on the street as part of a crime bill. Aside from the benefits to public safety that such a legion might deliver, I began to contemplate the effect on our industry.

Each officer presumably would require a portable radio, and each new vehicle would be equipped with a radio at a rate of, say, one for every three new officers. Coordinating this increased police activity also would require some communities to install additional channels, including additional repeaters, antennas, coaxial cable, etc. So, let's add the cost of constructing another 50 repeaters. Some of the new systems might be installed on privately owned towers, increasing site rentals for maybe half of the new systems.

Okay then, let's see what all of this equipment and service adds up to, employing average costs for high-quality equipment. Portable radios, $65 million; vehicular radios, $20 million; repeaters, $225,000; antennas, $200,000; installation, $4,125,000; and site rental, $270,000.

That's a subtotal of $89,820,000!

If we then add maintenance fees, extended warranties, a few miles of coaxial cable, combiners, encryption, professional services and the rest of the ancillary costs, it appears that the total bill will reach about $100 million, give or take a cop or a cable.

As you can imagine, not all of the money will be going to a single manufacturer or supplier. The cost of outfitting the various law enforcement agencies will be spread across the United States, benefiting thousands of dealers and suppliers. For the individual two-way shop, this is an opportunity to sell radios, improve its bottom line and extend its existing business with

Schwaninger, *MRT's* regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington, DC.

Regulating technology

local governments.

Now, how about all of those private security guards that are being employed by school districts to ensure that students can study and interact safely? Many of these guards are equipped with radios. Then, of course, there are the private citizens who make up the neighborhood watch groups. Most of these are using radios to stay in contact with their teams. Add to that the increased sales in central station alarm equipment, anti-auto theft equipment, retail store security systems, gate operation equipment and the host of other RF devices that function for the sole purpose of protection against crime.

Our industry is greatly affected by crime statistics and by public perceptions of the problem. When people feel unsafe in their homes and streets, they and their elected officials react, and the reaction often means the creation of new systems and deterrents that often result in greater demand for RF devices.

I am not, of course, suggesting that you root for a rash of violence in your community to spur sales. (My monsignor would have me saying "Hail Marys" until Bob Dole smiles.) I am suggesting that the industry recognize that a greater burden is being placed on it to devise electronic solutions in response to the public's fears about crime.

From a wholly business perspective, this is a great opportunity to sell RF equipment. From another perspective, this is an unfortunate reaction to what the public tells us is its No. 1 Concern: crime. It also appears to be an attempt to find electronic solutions to human frailties.

Whether you believe the cause of crime is the disintegration of the family unit, the erosion of human values or the failure to build enough prisons, the fact remains that the public's fear of crime sells radios. If you require additional proof, check out the television advertisements for cellular equipment that always picture a woman in a broken-down car in a bad neighborhood.

As an industry, we have the ability to devise listening devices to extend our protectors' ears, video systems that allow them to see through walls and data transmission systems that carry information faster than a speeding bullet. It is no wonder that local governments sometimes view our products as the way to make supermen out of their police officers.

What the participants in the industry should also recognize, however, is their individual responsibility in designing and selling electronic solutions to crime. The history of local government activities is rife with horror stories of suppliers who feathered their own nest and fouled the government's.

Sales of incompatible equipment have caused a networking nightmare for some unsuspecting police departments. Equipment has been sold for which no spectrum might be found for future use. Failures to produce high-quality installation, maintenance and system design all have led to the sale and operation of inferior systems in too many instances. Add to the unbalanced equation the too-often "closed bidding" scenario where the mayor's brother-in-law is the supplier and unloads overpriced, underperforming equipment on the local government, and the entire matter can make for frightening results.

Instead, local governments should be able to turn to manufacturers, designers, suppliers, frequency coordinators, operators, consultants, technicians and carriers for honest solutions to the daunting and pervasive crime problem. Then, we as an industry can collect our hundred-million-dollar check and be proud of the help we have provided to the public.

There is money to be made. Let's make sure that it's an honest buck.

EMCI projects SMR industry to serve 4.4 million subscribers by 1998

While the mobile radio industry is undergoing consolidation and conversion to digital technology, the existing specialized mobile radio (SMR) service continues to grow, according to MTA-EMCI, Washington, DC, in its *State of SMR and Digital Mobile Radio: 1993/1994*. EMCI's analysis of SMR operator results reveals that the industry added about 192,000 new units in 1993. The aggressive rollout of digital SMR and the promise of advanced voice and data services will drive the SMR market to serve 4.4 million subscribers by 1998.

EMCI estimates that by 1998 digital radios will account for about 66% of all radios in service and 90% of the annual radio sales. Analog radio sales will moderately decline during the next five years, and total mobile radio sales will continue to increase, reaching about 1.5 million annually by 1998.

Revenues per mobile unit are an important component of the financial health of existing analog and future digital SMR operators. Dispatch-only revenue per unit has remained steady for the past few years, and interconnected service continues to bring in higher revenues per unit. There was an increase in interconnected service revenues from $45 per month in 1991 to about $52 per month in 1993.

SMR operators experience the lowest churn rates when compared to cellular and paging services, according to EMCI. SMR industry churn returned to the levels experienced before the recession of 1991–1992. Monthly churn was reported to be 1.2% of all units in service. Over the past three years, cellular has had a monthly churn rate between 2.3% and 2.9%, and paging churn rates have been around 3% per month.

EMCI expects SMR industry churn to increase as the industry competes with cellular, personal communications services and other wireless technologies.

NABER begins technician certification testing on weekends

The National Association of Business and Educational Radio (NABER) has chosen Drake Training and Technologies in Bloomington, MN, as the new computerized exam administrator for the NABER Technician Certification Examination. This change will allow NABER to offer testing in the evenings and on weekends, and the number of testing sites has increased from 80 to 229 nationwide.

The NABER Certification Examination is computerized, consisting of 150 multiple choice questions, covering four primary areas: two-way radio and two-way systems technology; fault analysis, methodology and instrumentation (troubleshooting); FCC rules and regulations; soldering, hand-tool use and equipment installation.

To register for the exam, call NABER's central registration line at 800-294-EXAM between 7 a.m. and 6 p.m. (central time) Monday through Friday.

Three companies support Motorola's Site Connect Server desktop system

Motorola's Customer Owned Paging, part of the Paging Products Group, Boynton Beach, FL, has been demonstrating its Site Connect Server, a wireless communications server that allows people on the move, on site or nationwide to stay in touch when away from their desktop tools.

The server uses Vendor Independent Paging (VIP) to provide information from E-mail, calendar updates, telephone calls or monitoring system alerts. Site Connect Server can site connect-enable desktop, telephony or monitoring applications to be integrated with pagers and Personal Computer Memory Card International Association (PCMCIA) devices.

Since its introduction last fall, Motorola's Site Connect Server has gained support from many paging carriers and developers of desktop applications. WordPerfect, Orem, UT, has demonstrated connectivity between its WordPerfect Office 4.0 applications and wireless messaging.

MobileComm, Jackson, MS, is one of the first to make a commitment to support the Site Connect Server's VIP interface. MobileComm's nationwide messaging, MobileComm MessageLink and MobileComm CompuLink services, as well as local services, will use VIP to seamlessly interface with desktop, telephony and monitoring system applications.

SkyTel, Washington, DC, has announced connectivity to Site Connect Server and support to the VIP interface.

News

Coded Communications receives $4.3 million contract

Coded Communications, Carlsbad, CA, is entering negotiations for the award of a $4.3 million contract with Monroe County, NY. The contract will be for a total systems solution to provide the county's public safety agencies with a dedicated mobile data communications network. The contract will be the largest ever awarded to Coded Communications and will be delivered during 1994.

As the prime contractor and systems integrator, Coded will provide all system components, with the exception of the new computer-aided dispatch (CAD), which will be provided by PRC, McLean, VA. The communications system will include Coded's MCT-2200 DOS-based mobile computer terminals, a 9,600bps wireless data network, IQController software to manage data traffic load and a new radio system. The base equipment and CAD will go into a newly constructed public safety dispatch center in Rochester.

Coded will equip more than 500 mobile units for the Monroe County Sheriff and several area police departments. County fire stations and select emergency medical services facilities will be linked to the data network.

MobileComm expands to meet pager demand

MobileComm, Jackson, MS, has expanded and modernized its facilities to meet the needs of its growing paging retail network. To streamline the route from MobileComm to its more than 13,000 retailers nationwide, the company has upgraded its distribution center, adding a computer scanning system that keeps sophisticated tracking records of more than 900 variations of products. The company's Electronic Data Interface (EDI) also has simplified the placement and shipment of orders to and from retailers.

MobileComm is expanding its national activation center. The improved computerization and physical expansion of the center in Jackson, MS, allows customer service specialists to activate more pagers in less time. The retail activation staff has grown more than 500% in just over a year.

Centurion honors distributors, representatives, sales coordinators

Steven C. Bowles, sales and marketing vice president for Centurion International, Lincoln, NE, honored distributors, representatives and sales coordinators at the Communications Marketing Association national meeting.

Hutton Communications, Dallas, was named Distributor of the Year for the highest increase in overall sales from the previous year. Martin-Cavendar, Dallas, was given Representative of the Year for the highest increase in overall sales from the previous year. Curry Sales, Kansas City, MO, received the "Hound Dog" award for showing the most perseverance throughout the year.

Centurion also honored its own employees by presenting an award to the sales coordinators for their support to their customers.

PageSat acquires satellite earth station facilities

PageSat, Palo Alto, CA, has acquired additional satellite earth station facilities that will allow the company to offer capabilities that include satellite coverage into the Pacific Rim, South America and Europe on an as-need basis, as well as in North America. The new facilities are co-located in an international teleport adjacent to an MCI central office in the Northern California Bay Area.

This co-location eliminates the need to use a local exchange carrier and allows increased reliability with lower operational costs.

Sigtone acquires Interconnect Specialists product line

Sigtone, Winter Park, FL, has acquired the entire Interconnect Specialists (ISI) product line of telephone interconnect, microphones and other signaling products. Because of its high market recognition, Sigtone will continue to brand the products under the Interconnect Specialists name.

Selected Sigtec/Sigtone products and the Interconnect Specialists line of products will be manufactured in Sigtone's newly expanded Winter Park, FL, facilities.

Ericsson GE, Maxon enter into technology transfer, licensing agreement

Ericsson GE Mobile Communications, Lynchburg, VA, and Maxon America, Kansas City, MO, have signed a Memorandum of Understanding to enter into a technology transfer and licensing agreement to be finalized in mid-1994. After the agreement is final, Maxon will be licensed to manufacture and sell portable and mobile radios compatible with EGE's communications system, EDACS, in North America. The products will follow Ericsson GE's quality guidelines.

A similar agreement has been executed in Korea, where Kukjae Electronics was awarded a technology transfer and licensing agreement to manufacture EDACS two-way equipment for use in the Korean market.

Andrew installs distributed communications system for Denver Airport

Andrew, Orland Park, IL, has designed and installed a distributed communications system (DCS) for the new Denver International Airport. The DCS allows distribution and retransmission of mobile communications RF signals throughout the airport's enclosed areas, including the main terminal building, the airport office building, train and baggage tunnels, parking garages, the concourse and maintenance areas. Signals carried by the system include 800MHz and 900MHz trunking, UHF paging and conventional, wireline and non-wireline cellular.

Grayson Electronics acquires TSR Technologies

Grayson Electronics, a Forest, VA-based division of The Allen Telecom Group, has acquired TSR Technologies, Blacksburg, VA, producer of the Cellscope and Pagetracker system design, maintenance and fraud detection products for the cellular and paging markets. TSR recorded $1 million in sales during 1992 after rapid product takeoff earlier in the year. Grayson projects continued sales growth for the TSR product line in 1994 based on the 1993 sales performance, improvements to the product line and new product releases for the digital cellular and PCS markets.

Scientific Applications International acquires Syntonic Technology

Science Applications International (SAIC), San Diego, has signed a letter of intent with Syntonic Technology, Harrisburg, PA. SAIC's Intelligent Transportation Systems (ITS) Group will be merged with Syntonic to form a new, wholly owned subsidiary of SAIC. The new company will be in Harrisburg and will have estimated annual revenues of $75 million.

The SAIC divisions that will be part of the new subsidiary include the Electronic Toll and Traffic Management Division and the Intelligent Vehicle Highway Systems Division.

Communications Associates celebrates 15th Anniversary

Communications Associates, Joliet, IL, is celebrating its 15th year of service to the mobile communications industry. The company was started in 1979 as a division of Avionics Associates and became the first wholesale distributor of cellular products when the Chicago cellular system began in 1983. In 1984 Communications Associates was separately incorporated.

Visiplex acquires majority interest in Advanced Interactive Systems

Visiplex Communications, Deerfield, IL, parent company of a growing group of high-tech medical and security communications companies, has acquired a majority interest in Advanced Interactive Systems (AIS), Waltham, MA. AIS is a maker of advanced messaging systems for hospitals and industry.

Bee Electronics relocates

Bee Electronics has moved. The new address is 2120 Roberts Drive, Broadview, IL 60153. The phone and fax numbers will remain the same: phone, 800-336-3115; fax 800-345-2091.

Reader's choice

Of all the new products and services in the August 1993 issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, here is your opportunity to acquire more information on them. Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

System offers secure full-duplex communications

The **Telenexus** TNEX-2000 is a flexible, wireless communications system that provides local voice communications for virtually any work group and requires no FCC license. It offers full-duplex simultaneous conversations with as many as 16 portable units. Portable units can make telephone calls and can selectively call individual portables or groups of portables. Digital spread-spectrum modulation prevents eavesdropping.

Circle (500) on Fast Fact Card

Pager decodes formats, monitors CTCSS tones

The TP-150 VHF tone, voice and monitor pager from **Communication Research and Development (CRDC)** has a microprocessor-controlled FM receiver that decodes Motorola and GE formats or CTCSS tones for monitoring. Other features include dual call and group call addressing, two-channel capability, scanning, PC-programmable operation, vibrator option for silent mode, visual and audible low battery indicator and in-unit battery recharging capability.

Circle (501) on Fast Fact Card

Headset for cellular phones allows hands-free use

Miniset from **Cellabs** is a headset for handheld cellular phones that allows hands-free use, increased safety and no loss in audio quality. It covers only one ear, measures 1"H × 2"W × 4"L and weighs four ounces. The control unit box is powered by an internal 9V battery and draws no power from the phone.

Circle (502) on Fast Fact Card

Upgraded numeric pager presents extended features

Motorola introduces an upgraded replacement for its Bravo pager. The Bravo Classic is a numeric pager, enabling users to read callers' phone numbers from a 12-character, top-mounted LCD. Callers can include additional information like phone extensions and ID numbers by leaving messages longer than 12 characters. These messages get continued onto easily accessible "additional" screens. The Bravo Classic stores as many as 16 messages, which are retained in memory even with the pager switched off. Users also can lock as many as four messages into protected memory. Other features include backlit display, time-stamping of messages, audible or vibration alert, reminder alert and low-battery alert. The 3.1-ounce unit operates on one AA battery and measures 2.87"L × 1.95"H × 0.75"D.

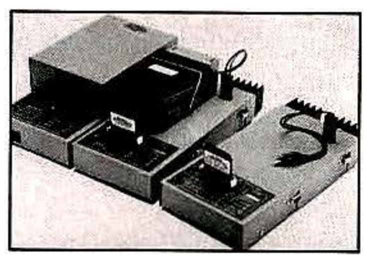
Circle (350) on Fast Fact Card

Digital trunking system enters second generation

The SmarTrunk II from **Selectone** is a digital trunking system for low-cost radiotelephone, fleet dispatch trunking and conventional radio operations. User features include store and send dialing, memory speedial and last-number redial. The system supports as many as 1,100 subscribers and as many as 16 trunking channels. The system's ST-852 Digital Trunking Controller is used with any full-duplex repeater or base station and a series of mobile logic boards installed inside the mobile or portable receivers. The signalling protocol deters unauthorized users, and the system provides call privacy. In the radiotelephone mode, the system supports mobile-to-landline, landline-to-mobile, and mobile-to-mobile selective calling. In the fleet dispatch mode, true PTT-only fleet trunking is now available. SmarTrunk II operates on any frequency band and operates with VHF and UHF transceivers from eight different manufacturers.

Circle (351) on Fast Fact Card

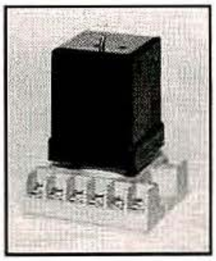
Battery test system determines the highest achievable capacity for NiCd, lead acid and nickel-metal hydride



The Astratec multicheck battery test system is now available through **Adcour** for use with NiCd, lead acid and nickel-metal hydride batteries. The system determines the battery's highest achievable capacity measured to the manufacturer's specifications. Once the battery is connected, the test becomes fully automatic. Up to six different batteries can be tested at one time. The system consists of a single power supply, test modules and calibration cards to match each battery's characteristics. A charge-discharge cycle is initiated with the push of a button, and completion is signalled by a buzzer. The results are automatically displayed on an LCD at the end of the test. Input power is 120V/240V ±10%, 47Hz–63Hz, user-selectable.

Circle (352) on Fast Fact Card

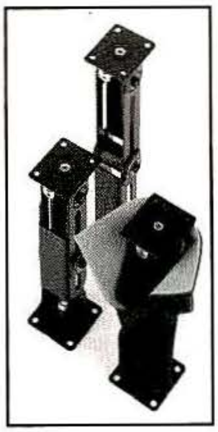
Plug converts transceiver set-up into alarm data reporting device



A microprocessor-based plug from **Schurman Electronics** adapts the signaling capability of the Radius GM300 transceiver to report alarms. The unit responds to a contact closure and prompts the radio to send a data burst every 10 seconds until it is reset or times out. The unit can be reset and tested over the air and operates on a community repeater.

Circle (353) on a Fast Fact Card

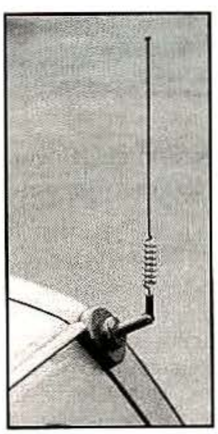
Pedestal mount telescopes to needs



The SDI 5811 series telescopic pedestal mount frm **Scientific Dimensions** allows exact placement of apparatus within a vehicle. The unit telescopes from 8" to 11" with a knob option for instant access to the telescoping function. Included is a Velcro-seamed decor wrap.

Circle (354) on Fast Fact Card

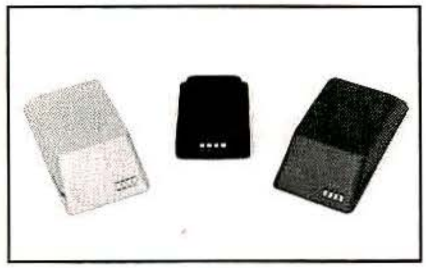
Swivel adaptor provides option for hatchback look-alike antennas



STI-CO Industries introduces the Hatchback Swivel Adapter for nonelevated feed trunk lip-mount disguised cellular look-alike antennas. The adaptor fits most hatchback cars, vans and four-wheel drive sports vehicles. It also can be utilized with STI-CO's nonelevated feed roof- and magnetic-mount cellular look-alike antennas.

Circle (355) on Fast Fact Card

Environmentally sound batteries available for rapid or standard charging



Nickel-metal hydride batteries for portable phones are available from **Advanced Fox Cellular.** The batteries contain no cadmium, lead, mercury or lithium. For rapid and standard charging, the batteries offer twice the capacity of similarly sized NiCd batteries. Models are available for Audiovox, Motorola, Mitsubishi, Nokia, Panasonic and Uniden phones.

Circle (356) on Fast Fact Card

New products

Mobile radio for 800MHz, 900MHz bands meets military sepcifications

The Viking GT series LTR mobile radio from **E.F. Johnson** comes in four models (low- and high-power versions in both 800MHz and 900MHz frequency bands) and it can be used in both LTR and conventional formats. The radio features 10-character display and programmable option buttons. It is capable of 20 systems, with 10 groups per system, with both system and group scan. The Viking GT meets all Military Standard 810 specs, including rain, shock and vibration.

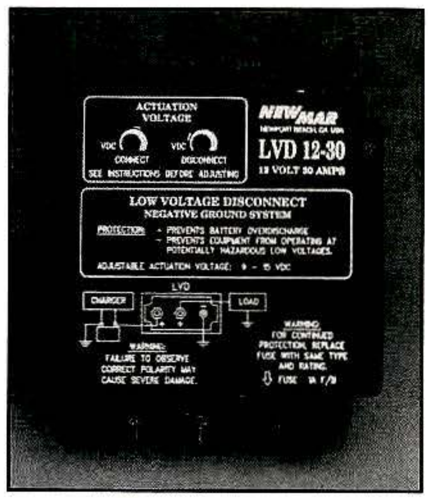
Circle (357) on Fast Fact Card

Digital recorder allows networking to create a 500-channel system

The PL 2000 digital recorder from **Atis** has a standard peripheral interface to permit the system to be equipped with an 8mm tape drive, optical disk drive and digital audio tape drive. Its architecture allows up to 64 recording channels in one rack or desktop module. Eight modules can be networked to provide an integrated system of over 500 channels. Only one CRT and keyboard is necessary for system operation. Digital silence encoding (DSE) marks and compresses silent periods to fully utilize storage media. Sixteen hours of instant recall is standard, with an option for as many as 270 hours. Remote access includes a comprehensive set of on-line diagnostics that identify faults to the component level.

Circle (358) on Fast Fact Card

Low voltage disconnect monitors battery using user-adjustable settings



The LVD 12-30 and LVD 24-20 low voltage disconnects from **Newmar** prevent over-discharge of back-up batteries when ac power is lost for an extended time. The units are wall-mountable and installed in-line with the power leads between the battery and the load. The monitor and control circuit checks back-up battery voltage and disconnects the load when voltage falls below a preset cut-off point. The load is automatically reconnected when the batteries are recharged. Levels are user-adjustable to accommodate different batteries and load conditions. The LVD 12-30 is for 12V systems up to 30A, and the LVD 24-20 is for 24V systems up to 20A.

Circle (359) on Fast Fact Card

Remote monitoring system allows off-site management of temperature, security, forward/reflected power and lighting for antenna towers

The RemoteLINQ ITM 100 real-time monitoring system from **Remote Monitoring of America** detects and responds to tower light and site power outages, temperature variations in shelters or radio racks, unauthorized entry and other site conditions. The system includes RemoteLINQ software, two current sensors, a temperature probe, one intrusion detector and a Hayes-compatible modem. Four-hour battery back-up and a photocell are also standard. Options include forward/reflected power sensors and a cellular radio package. The power monitor plugs in-line into a tower's antenna cable using standard "N" connectors. The RemoteLINQ includes a microprocessor and stored logic, interfaces for sensors, and a communications interface for a cellular phone, a land-line, or both.

Circle (360) on Fast Fact Card

TRILOGY

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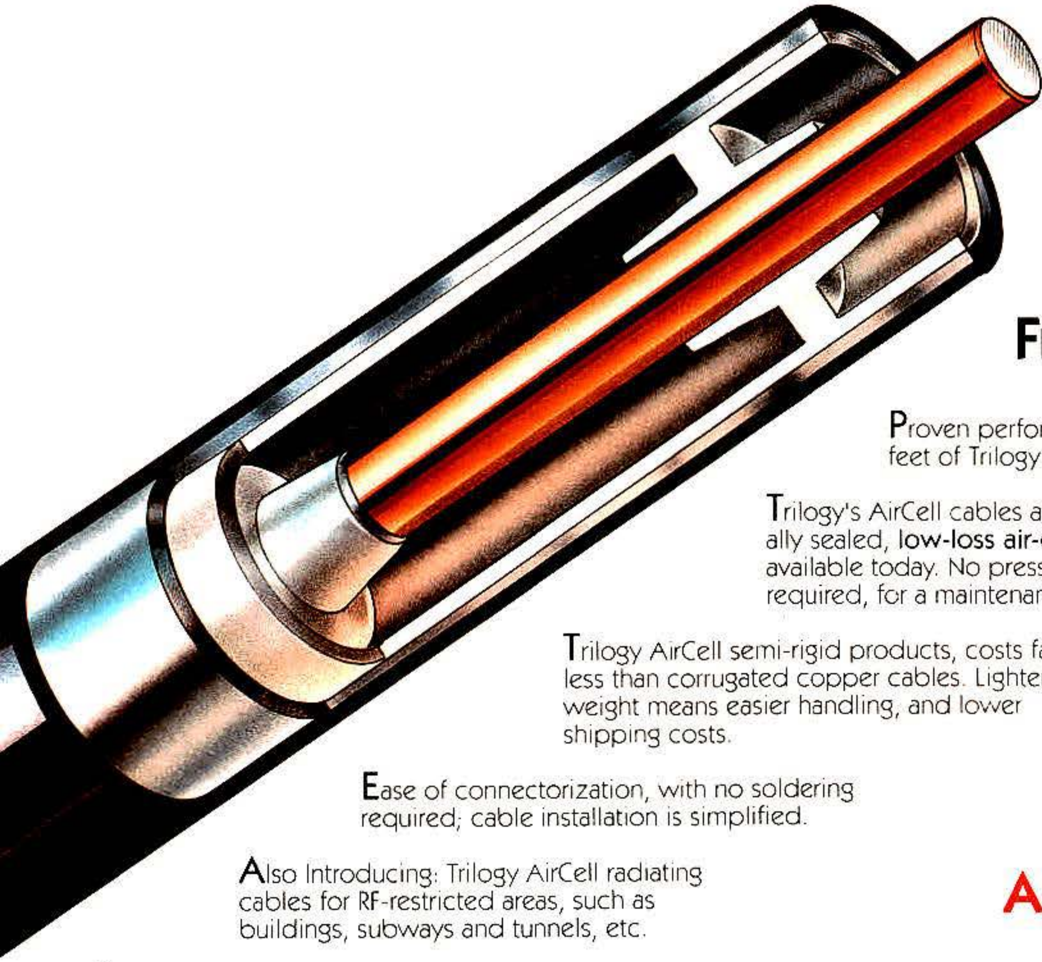

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Circle (95) on Fast Fact Card

New products

Coaxial cable assemblies feature low attenuation, small bending radius

Valuflex jumper cable assemblies from **Andrew** are designed to outperform braided cable assemblies. Manufactured from Heliax coaxial cable, Valuflex assemblies are designed for indoor use up to 3GHz. Applications include use in shelters, rack-to-rack and radio OEM. The jumpers feature lower attenuation with smaller diameter, higher RF shielding and a smaller bending radius. Valuflex jumpers are manufacturerd from Heliax coaxial cable type FSJ1-50 ¼" diameter for general connectivity; FSJ2-50A ³/₈" diameter for demanding applications; and ETS1-50T ¼" diameter for high power or plenum applications.

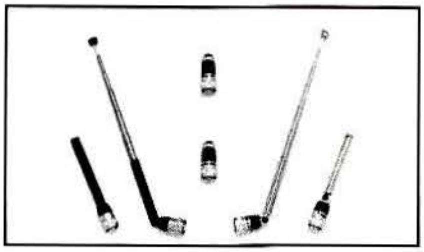
Circle (361) on Fast Fact Card

Mapping software aids RF path plotting with USGS topographic maps

SoftWright has released software to facilitate the easy plotting of RF paths on USGS topographic maps. The map crossing and indexing module of the Terrain Analysis Package will calculate the map crossing distances for each map on the path. The index of over 76,000 USGS topographic maps is included, enabling the user to print out a list of necessary maps. Other modules will calculate and plot profiles, path budgeting, and microwave and SCADA route maps.

Circle (362) on Fast Fact Card

Cellular antenna line includes telescoping, rubber duck and tilt models



Advanced Fox Cellular introduces a new line of antennas for all hand portable cellular phones. Models include gold-plated, black-alloy tilt and telescoping antennas; gold-plated 1" button antennas; 1", 3" and 6" rubber duck antennas; and replacement/retractable antennas with installation tool.

Circle (363) on Fast Fact Card

Two-piece FC/PC-style connector accommodates different fiber modes

Automatic Tool and Connector introduces a two-piece FC/PC-style connector with a keyed, threaded, one-piece backbone for easy field installation. The zirconia ferrule with pre-radiused end finish provides reflecting characteristics of ≤−35dB PC Polish, ≤−45dB Super PC. The connectors will accommodate single-mode and multi-mode fibers and are compatible with NTT FC and NEC D3 standards. Mean insertion loss is 0.1dB for multi-mode and 0.2dB for single mode.

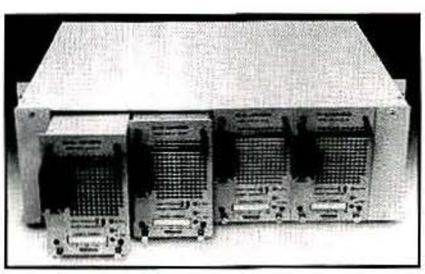
Circle (364) on Fast Fact Card

Deoxidizing solution to improve conductivity comes in various formats

DeoxIT from **Caig Laboratories** is a fact-acting deoxidizing solution that cleans, preserves, lubricates and improves conductivity on metal connector and contact surfaces. Applications include switches, potentiometers, relays, PCB edge connectors, batteries, faders, cables, jacks and plugs. DeoxIT contains deoxidizers, preservatives, conductivity enhancers, anti-tarnishing compounds, and arcing and RFI inhibitors. The solution prevents dissolved oxides and contaminants from reattaching to metal surfaces. The solution is available in spray, liquid, wipes and pen applicators.

Circle (365) on Fast Fact Card

Dc-to-dc converter offers increased power density, front connections

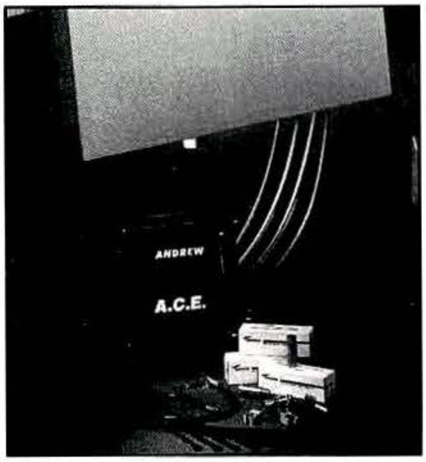


The series 1625 Modular dc-to-dc Converter System from **Wilmore Electronics** is now available in 24V-to-48V and 48V-to-24V versions. The system enables users to forgo using a second rectifier/battery plant in equipment sites needing multiple dc voltages. The 4,000W converter shelf/module system offers increased power density. The 23-inch converter requires only 7" of vertical rack space, allows front-connection wiring and can be equipped with as many as four 1,000W plug-in modules. Each converter module features an isolated, regulated, adjustable dc output; LED bargraph ammeter; output voltage test points; LED status indicators; and Form C alarm contacts.

Circle (366) on Fast Fact Card

New products

Communications extender distributes RF coverage inside structures



The Andrew Communications Extender (A.C.E.) from **Andrew** is for distributing clear, continuous RF coverage within buildings where traditional cell and micro-cell signals cannot penetrate. The A.C.E. kit includes small, 40dB-gain bi-directional amplifiers designed to receive, filter, amplify and retransmit cellular or trunked radio signals. Signals are gathered by a roof- or wall-mounted antenna external to the coverage area. Compatible with digital and analog signals, the A.C.E. has been granted FCC type acceptance under Part 22 for U.S. cellular "amps" and under Part 90 for U.S. 800MHz trunking applications.

Circle (367) on Fast Fact Card

Modular repeater combines receiver, exciter and amplifier into one unit

The Viking VX series repeater from **E.F. Johnson** is a compact 800MHz LTR unit that combines logic, receiver, exciter and power amplifier into a product under nine inches high. The Viking VX is a fully synthesized dealer/SMR complement to the Summit repeater, and it also can migrate to digital technology. Five high-spec Viking VX repeaters can be accommodated in less than 44 inches of rack space but still offer 75W power. The unit is completely modular for easy installation and maintenance, and it offers remote diagnostics and alarms. Viking Network capability can be added to the VX repeater.

Circle (368) on Fast Fact Card

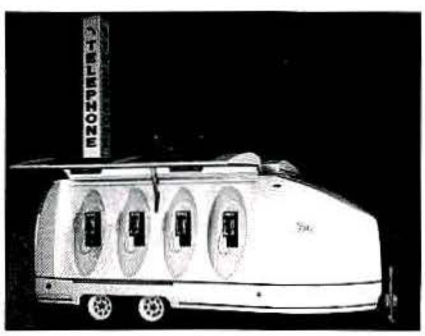
Desktop base station features wide bandwidth, automatic ac-to-dc transfer

The B/K EMV/DTB synthesized desktop base station from **Comm-Tech International** operates with a wide bandwidth of 136MHz–174MHz VHF at 15W–50W and 403MHz–470MHz UHF at 10W–40W. Features include 114 channels, CTCSS/DCS, user-programmable scan with priority mode, busy channel lockout, alphanumeric display, real-time clock, ANI encode, and automatic ac-to-dc transfer in case of ac mains power failure. Channel spacing is programmable to 12.5KHz or 25KHz. Options for the system include ANI decode and display, and speech security with an analog rolling code scrambler.

Circle (369) on Fast Fact Card

Mobile communications trailer puts cellular phone access in remote areas

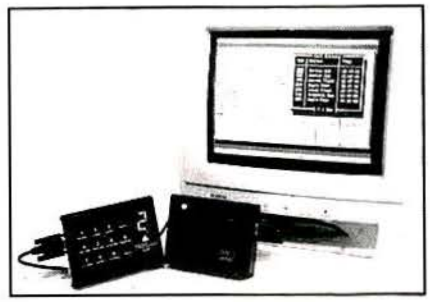
The TSG 2000 Mobile Communications Trailer from **Technology Services Group** provides remote communications functions. The design accommodates as many as 10 individual compartments with attached public cellular payphones. The fiber and aluminum trailer has independent wheel suspension and tandem axle. Vehicle brake, reverse, running and license plate lights conform to standard requirements. Solar cells and gel-filled batteries make the unit totally self-contained. Options include strobe light sign kit, air-cooled 1,500W gasoline generator, 120VAC invertor, fax machine assembly, dispensing ATM machine with



accessories and a handicap-access station.

Circle (370) on Fast Fact Card

Modem and reporter units work together to provide fleet dispatch



The model 1016C DTMF-ASCII modem and model 1012C mobile status reporter from **Pyramid Communications** work in conjunction to provide a full-featured fleet dispatch system. The 1016C modem connects between the base radio and an IBM-compatible PC or mini/mainframe. Included dispatch software features selective/group calling, horn honk capability, mobile interrogate, over-the-air programming, unlimited call history display, programmable status tags and multiple printouts. The modem and the status recorder are Speedcall 912-compatible and work in conjunction with ACS/Command Data concrete dispatch software.

Circle (371) on Fast Fact Card

Rechargeable lead batteries power different equipment simultaneously

The QB5 and QB2R high-capacity belt packs for hand-held radios and cellular phones are rechargeable, sealed lead-cell batteries from **Quantum Instruments.** The QB2R has a 3 ampere-hour, high-rate 9V battery, and the QB5 has a 2.1 ampere-hour, high-rate 12V battery. Housed in leather cases, the battery have a series of three LEDs to indicate charge remaining. The cells remain charged for months and can be recharged to full capacity without memory effect. Adapters and cables are available to fit most hand-helds, cellular phones and other equipment. One battery can be used for different equipment by switching adapters. A charger is supplied, and there are two output sockets for powering two pieces of equipment at once.

Circle (372) on Fast Fact Card

Literature

Catalog describes tool kits, specialty tools

A 288-page color catalog includes sections on tool kits; cases and carts; PC/computer service; telecom; LAN and fiber-optics; wire and cable; hand tools; power tools; metal working; soldering; static control; circuit boards; lighting; optical aids; test and measurement; and cleaning equipment. The catalog from **Jensen Tools** presents test equipment from Fluke, Tektronix, Microtest, B&K, Extech and other manufacturers. It also provides a source of hardware and accessories for network installation.

Circle (300) on Fast Fact Card

Catalog displays electronic parts, components

A 248-page catalog contains more then 20,000 high-demand parts and components, more than 1,000 of them new. Some of the categories listed in the catalog from **MCM Electronics** are semiconductors, television parts, power supplies, home security alarms, telephone parts and accessories; connectors, tools, batteries, speakers and VCR parts. Included is MCM's line of Tenma test equipment. The company has expanded its line of computer and cellular products and has introduced a selection of appliance repair parts.

Circle (301) on Fast Fact Card

Catalog covers commercial, industrial components

A 93-page catalog incorporates detailed specifications and outline drawings on a variety of passive components in the dc to 18GHz frequency range. Commercial, industrial and military components included in the catalog from **Trilithic** are fixed and tunable filters; fixed, high-power, programmable and variable attenuators; high-power loads; SPDT, SP4T and SP8T programmable switches; and built-to-order switching and control rack-mountable subsystems.

Circle (302) on Fast Fact Card

Manual includes tower safety information

A 46-page tower safety, inspection and maintenance manual for tower owners, FCC license holders and employers whose employees climb towers is available from **American Towers and Structures.** The manual includes required safety information for employees, including FCC policy statement excerpts; OSHA (1910.268) data; OSHA tower collapse data; OSHA memo and recommendations; E.I.A. inspection recommendations; accident prevention and safety plan; inspection and maintenance scope of work; inspection and maintenance report.

Circle (303) on Fast Fact Card

Handbook discusses wireless data

The *Wireless Data Handbook* is a practical examination of two-way, terrestrial alternatives from cellular based to dedicated packet switched offerings—planned, testing and real. Business sections explain which application characteristics best match available technical alternatives, reasons for slow user acceptance in a constrained market, likely airtime price trends and market tradeoffs. Technical chapters focus on leading protocols, differences in coverage depth, error impact and subscriber capacity of ARDIS, RAM and CDPD. Included are modem alternatives and their speed and price trends. The 350-page handbook from **Quantum Publishing** is targeted at technical and business planning staffs of cellular operating companies, manufacturing companies building wireless data equipment, modernizing SMRs and consultants advising clients on the practical applications of wireless data to their businesses.

Circle (304) on Fast Fact Card

People


Climie


Byers


Burns


Caldwell

William A. Climie departs Mobility Canada, Toronto, Ontario, as director of national retail sales to join Sinclair Radio Laboratories, Tonawanda, NY, as vice president and national sales manager for Canadian and export markets. He will be located at corporate headquarters in Aurora, Ontario.

Changes at Ora Electronics, Chatsworth, CA:

Bill Byers departs PacTel Teletrac, Inglewood, CA, as national accounts manager to join Ora as western regional sales manager.

Scott Burns exits the communications products division of Mitsubishi Electronics, America, as distributor sales force manager to become eastern regional sales manager for Ora.

John Caldwell leaves Kenwood USA's Mobile Electronics Group, Long Beach, CA, as national sales manager to join Ora as sales and marketing director.

Changes at RAM Mobile Data, New York:

Carl Robert Aron continues as chairman and relinquishes responsibility as chief executive officer at RAM Mobile Data USA as the company completes its development phase and seeks a new chief executive officer.

George Pappas exits RAM/BSE Paging in the Hawaii division as president to join RAM Mobile Data as executive vice president of operations.

Frederick J. Day, director of government relations for the Industrial Telecommunications Association (ITA), Arlington, VA, moves up to executive director of government relations.

R. James Evans, a principal of the communications consulting firm of Evans & Evans Associates, East Lansing, MI, died Oct. 20, 1993. He was a past president of APCO, a Fellow in the Radio Club of America, and a member of *MRT*'s editorial advisory board.

Raymond D. Heck leaves E-Max, Louisville, KY, as operations manager and sales associate to join SoftWright, Aurora, CO, in its marketing department.

Changes at Avtec, Gilbert, SC:

Troy Branning, president, advances to chief executive officer and continues as chairman of the board.

Michael Branning, electronic development manager, moves up to president.

Craig Lewis, electronic design engineer, steps up to electronic development manager.

Jack Goff, project engineer, advances to project engineering manager.

Richard Kneece, graduate of Georgia Tech, joins Avtec as quality assurance engineer.

Michael Mundy leaves the U. S. Air Force as a communications technician to become project engineer at Avtec.

Charles Drozd exits Metrscope as realtime software development engineer to join Avtec as a software engineer.

Mobile Radio Technology

The journal of mobile communications technology

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Mercy Contreras, *Publisher*
Darren Sextro, *Marketing Director*
Kathryn Buckley, *Promotions Manager*
Denise Kettler, *Promotions Coordinator*
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Letters from readers

Radiation guidelines:

An error was found in the "RF Radiation Guidelines for Communications Sites" by Raymond C. Trott, P.E., in the October 1993 issue.

The standards levels cited on page 12 should be in (mW/sq. cm.), not (mV/sq. cm), and the levels sited applied only to two frequency ranges listed in the ANSI/IEEE C95.1—1992.

Maximum permissible exposure for conrolled environment

Frequency Range (MHz)	Power Density, S (mW/sq. cm)	Average Time (minutes)
100–300	1.0	6
300–3,000	f/300	6

f = frequency in MHz

Maximum permissible exposure for uncontrolled environment

Frequency Range (MHz)	Power Density, S (mW/sq. cm)	Average Time (minutes)
100–300	0.2	30
300–3,000	f/1,500	30

f = frequency in MHz

Huy D. Nguyen, P.E.
Telecommunications Engineer
State of California
Department of General Services
Sacramento, CA

Mr. Trott's reply:

Mr. Nguyen is correct in both instances. The unit shown in the article was a typographical error and should have read mW/cm^2.

The standards of $1.0 mW/cm^2$ and $0.2 mW/cm^2$ indeed are for 100MHz–300MHz only; however, because most communications facilities contain RF sources across a wide spectrum both inside and outside of the 100MHz–300MHz range, the *worst case* standard normally is used, since it would be difficult to quantify the contributions from all of the different sources across the spectrum.

My thanks to Mr. Nguyen for bringing these issues to the readers' attention.

Raymond C. Trott, P.E.
President
Raymond C. Trott Consulting Engineers
Irving, TX

Buyers' Guide

Please turn to page 91 of the December 1993 Buyers' Guide issue and add this company to the list:

TeleLink Technologies
2696 Nootka St.
Vancouver, British Columbia
V5M 3M5
Canada
604-254-7880
800-567-8884
Fax: 604-254-1853

On page 32, please add the name TeleLink Technologies under the heading of "Paging Terminals."

Fast Fact Card comments:

The toughest problems facing me on the job are locating low-cost components and assemblies and finding new equipment at low cost for retail, rental and leasing.

Ernest A. Erickson
Applied Electronics
Racine, WI

The toughest problems facing me on the job are being a small dealer and too much regulation.

Scott Porter
Illinois Radio Service
Champaign, IL

The two toughest problems facing me on the job are:

- Reliable radio equipment that is affordable to the the small business user.
- Lack of awareness of RFI by communications systems users, and the unwillingness to purchase solutions.

Dennis E. Welch
DNL Meters & RF
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Stuart Meyer
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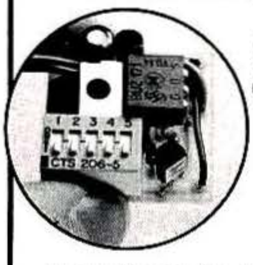

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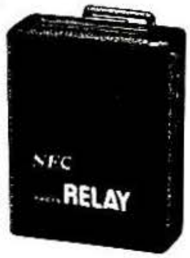

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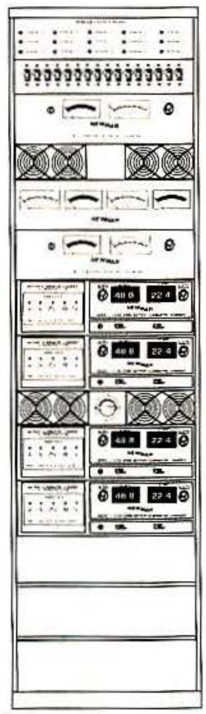

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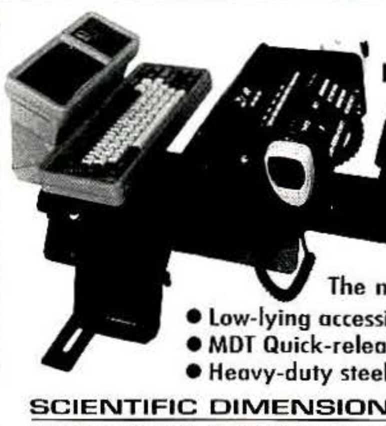

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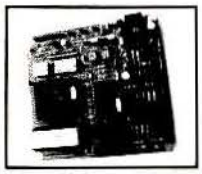

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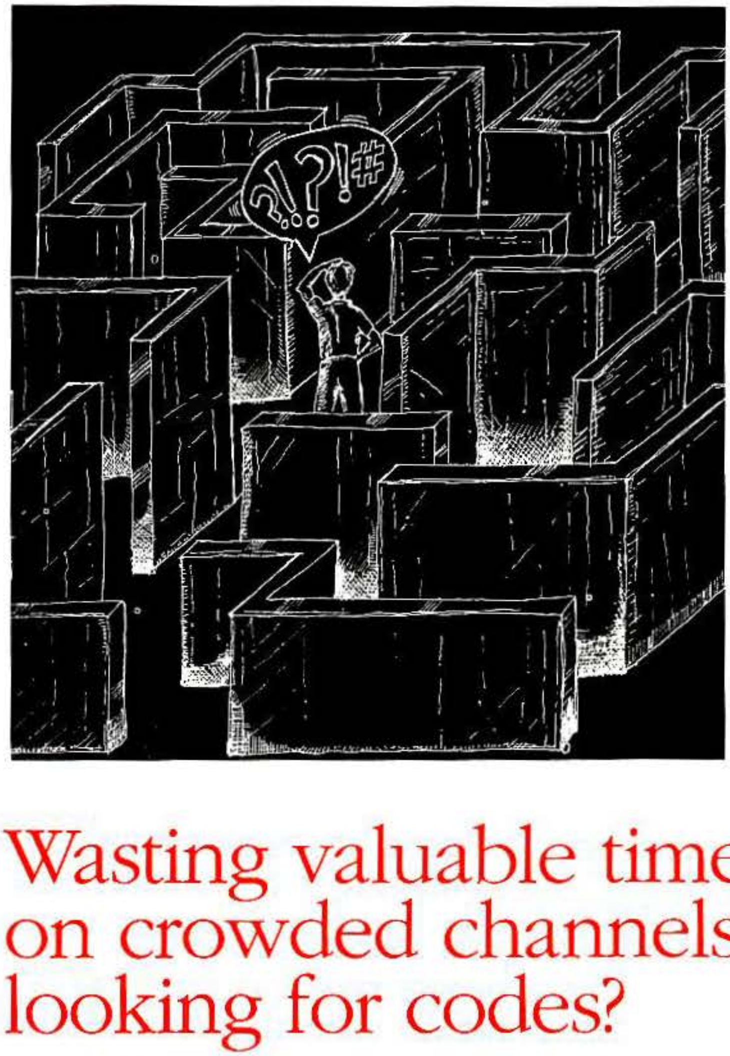

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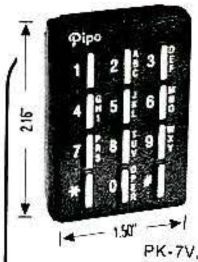

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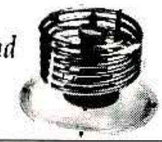

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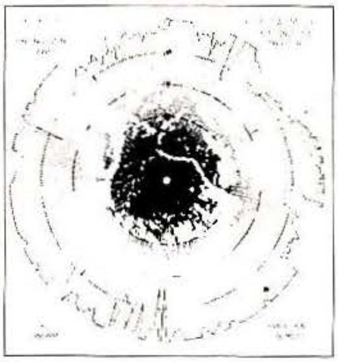

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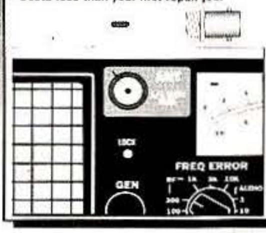

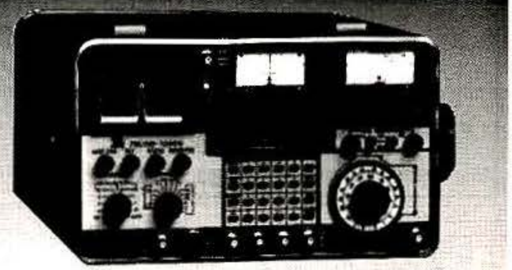

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Company	Page Number	Fast Fact Number	Advertiser Hotline
AAT Communications Corp.	125	158	908-417-3993
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Astron Corp.	41	36	714-458-7277
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A W Enterprises	43	38	800-334-4884
BEE Electronics Inc.	82	72	708-345-0337
Bendix/King	27	24	800-648-0947
Bird Electronics Corp.	57	50	216-248-1200
Bramco Inc.	88,117	101,140	513-773-6255
Cartwright Communications	96,106	94	800-543-8614
CELWAVE	19	17	800-321-4700
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Interactive Systems, Inc.	86,88	86,100	703-812-8270
International Crystal Mfg.	80	77	405-236-3741
Intl. Public Safety Assoc.	52	45	203-847-9679
JPS Communications	62	55	919-790-1011
Kenwood U.S.A. Corporation	65	58	310-639-4200
KNS Electronics Inc.	98	96	408-432-8100
Larsen Electronics	39	35	800-426-1656
Lazer Beepers, Inc.	123	155	800-354-3405
Le BLANC	11	9	214-934-1894
Lett Electronics Co.	115	138	800-530-5550
Maxrad, Inc.	73	69	800-323-9122
McManus Communications	107		501-763-6250
Mechem Electronics	113	130	703-373-3888
Megahertz Technology, Inc.	108	117	214-341-1119
Meridian Communications	31	28	818-888-7000
Microflect	67	61	503-363-9267
Midian Electronics Inc.	59	51	800-MID-IANS
Midland International LMR	21	19	800-MID-LAND
Mobile Mark, Inc.	70	65	800-648-2800
Modular Communication Systems	75	70	818-764-1333
Monark International Corp.	99	80	816-891-0700
R P Moses & Co., Inc.	109	123	516-679-8774
Motorola C & E	125	160	708-576-5484
Motorola Government	17	102	800-235-9590
MX-Com, Inc.	7	7	800-638-5577
N.A.B.E.R.	124	157	800-759-0300
NATCOM,Inc.	42,101	37,98	800-844-8287
NATCOM, Inc.	107	114	800-844-8287
New Mar	107	115	714-751-0488
Norcomm Corp.	93	92	916-477-8400
Norton Engineering	120	144	703-938-5745
Omnicron Electronics	86	85	203-928-0377
Optoelectronics, Inc.	111	127	800-327-5912
Orbacom Systems Inc.	23	20	609-829-4455
PanaVise Products Inc.	34	30	702-353-2900
Pekaar Communication, Inc.	114	134	201-772-0704
Percon Corporation	127	164	716-386-6015
Photocomm, Inc.	84	83	800-223-9580
Pipo Communications	118	141	916-644-5444
Pirod, Inc.	79	76	219-936-4221
Polaris Industries	110	125	800-752-3571
Polyphaser Corp.	30	27	800-325-7170
Pyramid Communications	121	149	414-730-4190
Radiomate	64	57	800-346-6442
The Radio Shop	107	113	713-526-8000
Radio Wholesale	113	131	800-53R-ADIO
Ramsey Electronics	114	133	716-924-4560
RCW Distributing	109	122	800-726-9015
RELM Communications	45	40	317-545-4281
Ritron, Inc.	81	79	800-USA-1USA
Rocky Mountain Comms, Inc.	120		303-526-5454
Sabre Communications	102	99	712-258-6690
Santa Fe Distributing	89	87	913-492-8288
Schlumberger Technologies	29	26	800-225-5765
Scientific Dimensions Inc.	108	116	505-345-8674
Sentry USA	120	145	407-773-6090
Sharp Communication	110	126	800-548-2484
Shinwa Communications of Am.	38	34	800-627-4722
Sinclair Radio Laboratories	47,98	41,97	800-288-2763
SMC Electro-Mount	60	53	800-527-1079
Softwright	121	150	303-344-5486
Solar Electric Specialties	80	78	800-344-2003
Stancil Corporation	69	64	714-546-2002
Sti-Co Industries, Inc.	36	32	716-662-2680
Tait Electronics	33	29	
Tait Electronics USA, Inc.	14	12	713-984-8684
Telemessaging Devices Inc.	90	88	800-645-4595
Telepoint, Inc.	95	93	310-652-3666
Telewave, Inc.	83	81	415-968-4400
Telex Communications, Inc.	20	18	800-554-0716
TGA Systems Inc.	48	42	404-441-2100
Times Microwave Systems	91	90	203-949-8400
Tower Watch	127	162	800-475-1780
TPL Communications, Inc.	56	49	213-256-3000
Transcrypt International Ltd	3		800-228-0226
Trident Micro Systems	85	84	800-798-7881
Trilogy Communications Inc.	97	95	601-932-4461
Trylon Manufacturing Co. Ltd.	84	82	519-669-5421
TX RX Systems Inc.	54	47	716-549-4700
Uniden Corp. of America	9	8	817-858-3300
UTC Service Corp.	122	152	202-872-1268
Valmont Industries, Inc.	28	25	402-359-2201
Vega, A Mark IV Company	1	4	818-442-0782
Versatel Communications	119	143	800-456-5548
Vertex/Yaesu USA	IBC	2	310-404-2700
Vocom/RF Corporation	18	16	800-USA-MADE
WAVETEK	12	10	800-245-6356
West Tennessee Comm's	106	111	800-249-1250
WirelessWorld Conference	71	66	
WirelessWorld Tapes	55	48	
Zetron, Inc.	49,87	43,87	206-820-6363

ID-8 **$89.95**

Automatic Morse Station Identifier. Meets all FCC ID Requirements. Fully field programmable with included keypad. 1.85" x 1.12" x .35"

CC-1/CR-1 **$49.95 each**

Surface Mount Component Kits for repairing SMT circuits. CC-1 for capacitors/CR-1 for resistors.

TP-38 **$399.00**

Shared Repeater Tone Panel. Full function, microprocessor controlled. 19.0" x 1.7" x 6.0"

TE-64 **$79.95**

Self-contained Encoder, Rotary Dial Selection. Great for the Benchtop. 5.25" x 3.3" x 1.7"

TE-12P **$89.95**

Self-contained CTCSS or Burst Encoder. Each dial position is field programmable. 5.25" x 3.3" x 1.7"

PE-1000 **$224.95**

Desktop Paging Encoder. Two-tone sequential, other formats available. 7.5" x 7.8" x 2.7"

PE-2P **$54.95**

Two-tone Sequential Encoder. Sub-assembly mounts inside radio or other enclosure. Multiple call capability. 1.25" x 2.0" x .4"

SD-1000 **$59.95**

Two-tone Sequential Decoder. Programmable unit provides switched outputs from two-tone paging calls. 1.25" x 2.0" x .4"

DTD-1 **$59.95**

Single Function DTMF Decoder. Provides switch outputs via DTMF. 1.25" x 2.0" x .4"

PE-4/PE-15 **$99.95**

Multiple Call POCSAG (RPC-1) Paging Encoders. Where direct control of local area paging is desired. 1.78" x 1.03" x .35"

DCS-23 **$59.95**

Digital Coded Squelch Encoder-Decoder. Programmable to all codes. 1.36" x 1.18" x .25"

TS-32P **$57.95**

Programmable CTCSS Encoder-Decoder. Tone squelch for any FM transceiver. 1.25" x 2.0" x .4"

TS-64 **$64.95**

Sub-miniature Programmable CTCSS Encoder-Decoder. 1.7" x .78" x .25"

SS-32SMP **$27.95**

Sub-miniature CTCSS Encoder. Jumper programmable. .53" x 1.0" x .16"

SS-32PA **$28.95**

Programmable CTCSS Encoder. Custom tones or audible tones also available. .9" x 1.3" x .4"

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